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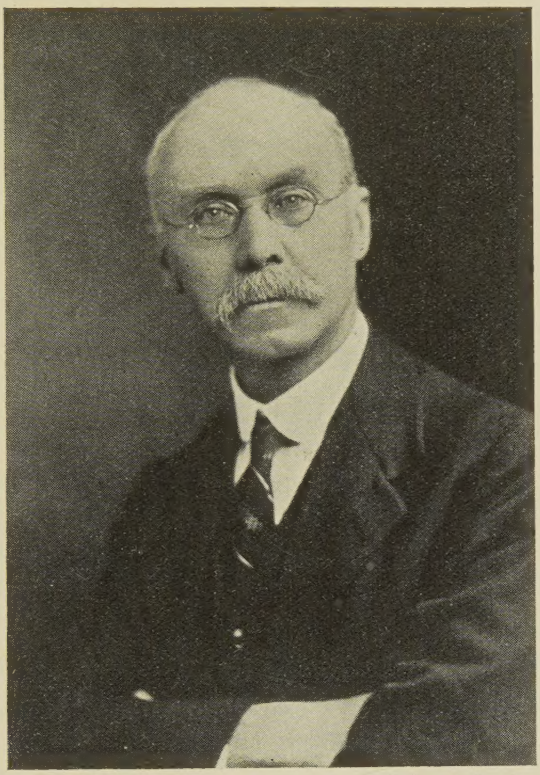

Lafayette, London.

Joseph Thomas Cunningham.
(1859–1935).

CUNNINGHAM learned his zoology from Rolleston at Oxford, taking a first class degree in natural science in 1881, after a first class in mathematical moderations and a Brackenbury scholarship at Balliol. His plans for research were interrupted in the autumn by a summons from Professor Ray Lankester to demonstrate zoology at University College, London, and he was inducted to acquire teaching experience in the low attic room, hot with fishtail gas-burners, where fifty enthusiastic and conceited students

regretted the departure of A. G. Bourne to be Professor at Madras. The best men took advantage of the knowledge in an able brain fresh from the schools; for the rest of us the relations of shy and inexperienced students with a shy and inexperienced B. A. made him unhappy. It was therefore with delight that, after the summer term, a fellowship at University College Oxford enabled Cunningham to pass from our purgatory to the zoologist's paradise at Naples.

From the Stazione Zoologica he published briefly his remarkable description of the nephridial ejection in *Aplysia* of living cells containing renal concretions. "My first paper," he said, reminiscently, when I quoted it to him in an argument, four months ago. In the fifty-two years since he wrote it, he had never ceased experiment, never slacked in curiosity. Characteristic of his research was always the welcome accorded to unanticipated results and his total disregard for absence of desirable facilities and apparatus.

This quality was taxed to the utmost when in 1887 he accepted from Ray Lankester the appointment to be Naturalist to the Marine Biological Association of the United Kingdom. He had been appointed Assistant Professor of Natural History at Edinburgh in 1883, and for three years had charge of the Marine Laboratory at Granton, giving opportunity for his paper on "Reproductive elements in *Myxine*" (Q. J. M. S. 1886). Now high hopes were held out of an illustrious career. He knew the great position which Dohrn's station and its naturalists at Naples held among the world's zoologists, and Lankester confidently believed that in a very few years his station at Plymouth would be of equal rank in a subject of recognized international importance. Lankester has been proved by Dr. Allen to have been right, except as to chronology.

When Cunningham took his place as Naturalist, "the work was carried on from August to November in a small room hired for the purpose near the fish quay; from November to June 1888, in a single room in the laboratory without a constant supply of sea-water."[1]) From then onwards the laboratory turned out continuous work, through the self-sacrificing labours of Cunningham, Heap, G. C. Bourne, Weldon, Fowler, Garstang and others; but, when I occupied a table there in 1893, the attendants consisted of an engineer, a fisherman, and an incompetent

[1]) Journ. Mar. Biol. Ass., Vol. I, N. S.; p. 10.

laboratory youth, while for weeks the great laboratory was inhabited by Cunningham at a table on the north side and myself at a table on the south side, and by no one else.

It was a great disappointment, which is not reflected in the character of his work. In the history of our knowledge of the lives of fishes, particularly of flatfishes, Cunningham's work during his ten years as M. B. A. Naturalist must always take a leading place.[2]) When he resigned that post in 1897, he was still for five years a specialist on marketable fishes, as lecturer to the Technical Instruction Committee, Cornwall; but from 1902 to 1926 his main occupation was in the teaching of general zoology, from 1917 as lecturer to the East London College, University of London. This is the period of his publications on general biology, including his bold hypothesis of a mechanism through which changes in organs, due to use and activity, might be transmitted to the corresponding organs of the offspring ("Hormones and Heredity", 1922).

Always he followed research, and accumulated a surprisingly large first-hand knowledge on very various biological problems, which, with wide reading, made him one of the most learned of his contemporaries. A striking illustration of this occurred at the Edinburgh Meeting of the British Association in 1921. A long paper by an esteemed zoologist was illustrated by beautiful photographs of feathers, the significance and connexion of which were not made so plain to the audience as they would have been made thirty years earlier by the same distinguished man. Cunningham stood up after the lecture and in some seven minutes, basing what he said primarily on his own researches, gave us a concise and complete account of the feathers which we had seen and their relation to each other. It was unexpected, it was masterly, and we were all grateful.

At the Linnean Society, in 1929, the account of Dr. G. S. Carter's South American exploration contained the suggestion that the pelvic filaments of the male lepidosiren provide for larval respiration by emitting oxygen into the nesting burrow. In the discussion, Cunningham pointed out that he had published this suggestion some years earlier Its importance was obviously increased by Dr. Carter's ascertainment that the swamp water was almost wholly

2) Journ. Mar. Biol. Ass., *passim*, 1888—1898; "A Treatise on the Common Sole", 1890; "Marketable Marine Fishes of the British Isles", 1896; "Coloration of Skins of Fishes", Phil. Trans., 1893; etc. etc.

irrespirable, and in 1930 Cunningham went out to the Amazon with a friend and, at the age of 72, made direct experiments confirming his hypothesis.

His remarks were at times affected by an inability, like colour-blindness, to appreciate personal effects of the words on his hearers, and he would be astonished to find that someone was wounded or indignant at what seemed to him a useful statement of fact or an amusing comment. This troubled his relations with many real friends, and disproportionately hindered the recognition of his great gifts and services. It was a genuine puzzle to him, because he was an extremely kind-hearted man, conscious of good work and of wishing well to all around him.

His happy married life was grieved by the loss of his only son in the War, but reached from his earliest thirties to his sudden death. Pursuing research and rejoicing in discovery, for more than half a century he did a full man's work as pioneer in new paths of knowledge and logician in recondite thought. Ecclesiastes sums him best: — "Live joyfully with the wife whom thou lovest all the days of the life of thy vanity .... for that is thy portion in life, and in thy labour. .... The race is not to the swift, nor the battle to the strong, neither yet bread to the wise nor yet riches to men of understanding. .... There is nothing better for a man, than that he should eat and drink, and that he should make his soul enjoy good in his labour."

G. P. B.

The Philosophic Basis of Statistical Analysis.

By

H. J. Buchanan-Wollaston,
Fisheries Laboratory, Lowestoft.

Introduction.

MODERN statistical analysis is founded on common-sense principles. Statistical concepts are perfectly easy to understand when clearly defined. Unfortunately such lengthy description is necessary for this clear definition that a kind of descriptive metaphor has grown up among statisticians. This is often most misleading. To mention one instance, the term "normal sample" is used to mean a sample which, on the assumption that it is a random sample, does not show itself to be very unlikely to have arisen from a population having a close resemblance to a population of which the frequency distribution is defined by the normal error function. In the example given two words are used to cover a concept which needs at least forty-five words for its clear definition. Yet the term "normal sample" is often used to cover even a still larger concept.

The descriptive metaphor I have mentioned is responsible for most of the mistrust of statistical methods which is shown by many workers. They very naturally assume that phrases are intended to be understood in their literal sense. Yet such is hardly ever the case. The definition in statistical metaphor, "something is A", nearly always means "the thing may be used in this particular case and in this particular manner as if it were A". If I choose to use a square iron bar as a hammer, an objection to my use of the word "hammer" for the iron bar is not a criticism of my use of the bar as a hammer. Useful criticism would suggest a better tool than the bar, if such could be got in the time available.

Every thinking being wishes to find the most reasonable explanations for his experiences. These include the most important experiences of the scientific observer, namely, his observations. No one doubts that the finding of such explanations in everyday life is an absolute necessity of existence. Without knowledge of cause and effect few of

us could survive even for a day. Every link which connects observations together is a step towards their explanation, and the longer the chain and the more observations are connected by it the more complete is the explanation. If any part of a particular experience chain can be expressed in plain language which everybody can understand, the chain is thereby made more complete, since such expression *always* links up many experiences from other chains. This general intelligibility *ipso facto* makes a science more complete. It is a fundamental necessity for the advance of science.

It is necessary to lay emphasis on the objects of science for the reason that there are statisticians who do not regard simplicity of explanation as necessary for scientific advance. They are content merely to connect observations together in the most convenient manner, without any thought of the immense loss of knowledge consequent on the neglect of what everyone understands by "explanation". There is no need to define this word closely, but it certainly implies that the "explained" observations have been connected in some way with other experiences.

There is no great dividing line, in the mathematical sense, between the equation

$$y = bx$$

and the equation

$$y = a + bx + cx^2 + dx^3 + \ldots .$$

Philosophically, however, there is a great difference between their meanings. The first expresses ordinary proportionality between two things, the second almost anything you like. The first is, the second is certainly *not* an *explanation* of the relation between one thing and another. The difference is that between a "natural law" and a "graduation formula" of which the first is and the second is not explanatory. It is preferable to search for "natural laws" connecting phenomena, even if there are unexplainable variations from these laws, rather than to find an empirical graduation formula which may appear to be the better "fit" to the observations. It should be remembered that a graduation formula may be made to fit anything. It may be the case, particularly in a new branch of science, that simple explanations cannot be found for observed phenomena. We may then graduate our observations in as simple a manner as possible with the idea that other observations, made simultaneously or at other times and places, may fall into line with them by requiring a graduation formula of the same type. If this happens the graduation formula acquires the status of an explanation or natural law of a kind. Even in such cases, however, it is preferable that the formula should be self-explanatory in the sense that it is capable of explaining how the phenomena may be expected to have arisen. If the deviations of the observations from the formula are symmetrical, we may say that the natural law it represents accounts for the observations within a given degree of precision. If there is a bias in these deviations, the cause of such bias

should be sought for. Sometimes it is preferable to leave it at a mere statement of the existence of the bias, in the hope of future explanation.

Among the most important explanations of phenomena are certain theoretical frequency distributions the occurrence of which in natural phenomena may be expected *a priori* in certain conditions. Much the most important of these is the binomial distribution, which in practice may be considered as identical with its limits, the normal distribution or Poisson's series, according to circumstances. In Pearson's Type III distribution the square roots of the observations and in the Galton-Macalister the logarithms of the observations conform to the normal law. All these distributions and several others are approximate expressions in certain conditions, of the natural law of chance, as represented by the throw of a number of dice[1]).

The notion of chance is the very foundation of statistics, and it should be understood that it *always* means exactly what the man in the street means by chance[2]). In nature, however, it is not coins or dice which are thrown but length-elements, weight elements, frequency-elements, and so on. We may prefer sometimes to think of a toss-up in the condition-elements producing these length-elements and so on. The chief characteristic of chance is that nobody attempts to account for it. It is unaccountable without complete knowledge of every influence which acts upon our observations. This is not to say that the chance element may not be eliminated to a certain extent by greater precision of observations but it always enters largely into the only way it is possible to make observations.

The Functions of Statistical Analysis.

It is not the function of the statistical analyst to formulate hypotheses in explanation of observations. This is the scientist's business. Knowledge of the laws of chance and of various mathematical distributions will no doubt help him in his choice of explanatory hypotheses. His previous experiences, however, and his powers of reasoning both deductive and inductive are the things he must depend on in the main. The scientist examines his data, and decides on a "theory" or an idea which he believes to be at any rate partially

[1]) It is quite likely that other types of Pearson's generalized frequency-distribution besides Type III may be *expected* to arise in nature in certain conditions. The distribution is founded on the theory of chance variations, and is not a purely empirical formula. I do not consider the mere fact that one of Pearson's types "fits" data offers an *explanation* of the data unless the particular laws of chance it represents are known to be reasonable in the circumstances. Generally speaking Pearson's types are not useful for the purposes of statistical tests since the distributions of statistics connected with them have not been tabulated. They cover such a wide variety of forms that such tabulation seems hardly possible. Pearson's distribution is not fully comprehensive. For instance it does not include the Galton-Macalister, which is of frequent service in statistics.

[2]) The throw of a number of dice with a great number of sides or the chance of drawing given cards from a very large number of mixed-up packs.

explanatory. He wishes then to satisfy himself that his explanation is not shown by the data themselves to be unreasonable, realizing that the element of chance enters into his methods of collecting data.

Statistical analysis affords the only means for allowing correctly for the chance element present in the collection of data.

The reasons why such analysis is necessary in science is because it is generally impossible to observe a whole population of measureable characters or numbers. We must be content with measuring or counting a sample[1]).

Random Sampling.

Every possible effort should be made, and usually is made, to ensure that the sample is a random sample. The soundness of statistical analysis depends entirely on this randomness in sampling. It may be said, too, that the whole process of inductive reasoning from the sample to the population depends on this randomness, or on a *known* lack of randomness. Thus statistical analysis is merely a part of the only sound way of inductive reasoning, which is itself the only way of scientific advance. Statistical tests of inductions are then not only desirable but necessary for the establishment of advances in science.

The definition of a random sample is perfectly simple. The sample is such that the mean chance of obtaining in it any particular measurement or number from the population in question is exactly equal to the proportional frequency of that measurement or number in the population. The number of times the particular number or measurement occurs in the sample varies in exactly the same way as does the number of times a particular number on a perfectly unbiassed die will turn up in a succession of throws. The chance of a three on an unbiassed cubical die is exactly $\frac{1}{6}$, but this does not mean that a three will occur exactly ten times in every set of sixty throws. The number of occurrences varies in accordance with the binomial law,

$$\left(\frac{1}{6}+\frac{5}{6}\right)^n, \text{ the general form being } (p+q)^n$$

where n is the number of throws. In a random sample the occurrence of any number or measurement varies in a very similar way; the variation is due to pure chance, as represented by throws of dice[2]).

Though ideal randomness in sampling is rarely, if ever, obtainable, yet no other kind of sampling is of any service at all in inductive reasoning. Every possible effort should be made to attain it, since we can get nowhere without assuming that our samples are random

[1]) Even the whole population sampled may be considered in many cases to be a random sample of a still larger or even an infinite imaginary population which exhibits in perfection the laws which the finite population exhibits imperfectly.

[2]) Since a sample is usually *limited in number*, and it is the occurrence *together* of a great number of different measurements which is being considered, it is plain that the number of times each measurement occurs is influenced by the occurrence of every other. Thus the law of chance acting in such cases is the multinomial, which is merely an extension of the binomial.

samples. This infers that they are truly representative of the population from which they are drawn, within the limits of chance variation. The extent of this variation may be estimated from the sample itself as will be explained later.

It is an essential in random sampling that the taking of one individual from the population should not affect the chances of taking any other. The "draws" must be entirely independent of each other, and the population must be so large that the taking of an entire sample does not affect appreciably the proportions of individuals differing in the measureable character in question which remain in the population. This is what is meant by the assumption of an "infinite" population. It is only necessary that the population should be very large in comparison with the sample. For instance, from a catch of ten baskets of fish say we measure four baskets. If then without returning these fish to the catch we measure two more baskets of fish, we cannot say that we are taking random samples of measurements from the same population of measurements in the two cases. Taking the first sample has evidently affected the proportions of the remaining measurements. Indeed every measurement made affects the chances of the recurrence of that measurement and of the occurrence of every other.

We must be clear in our minds, too, as to the real character of the population being sampled. For instance, it is clear that a trawl does not draw a random sample of the fish of a particular species which are present on the sea bottom. The population sampled is of a restricted kind.

We know then that the chance element enters into our method of sampling from a population, and must assume that our samples are random samples from a population which is infinite in the statistical sense. Any explanation which does not take the chance element into consideration must be therefore an erroneous explanation; yet if a part of the explanation is ascribed to chance, the explanation cannot be regarded as complete.

Statistical analysis aims at a compromise between full explanation which may not be real, and partial explanation which, while likely to be real, is not sufficiently complete.

For reasons already stated it is desirable that explanations of data should be as simple as possible. The data themselves often suggest a complicated explanation, but the temptation to consider that the data are exact and not subject to random sampling error must be resisted.

The Purpose of Statistical Analysis.

The purpose of statistical analysis is to find out whether deviations of data, from the values which they would have if our simple explanations were true and the *whole* population of measureable characters were examined, are likely to have arisen by chance. If this is so, then, so far as the data are concerned, there is no reason to assume that our explanations are incorrect.

Statistical analysis is concerned with the data only. It can never

prove that an explanation or hypothesis is true or even reasonable except in so far as the data do not show it to be unreasonable. The hypothesis should be such that it is acceptable on *a priori* grounds if the data do not show it to be unlikely to be true. This point is often misunderstood by scientific workers who make use of statistical analysis. They think that a hypothesis is proved to be true if not shown by data to be unlikely to be true. They forget that there is often a multitude of alternative hypotheses any of which may account for the data and that none of these except the one chosen have been considered in the analysis. The chosen hypothesis is merely that which is considered by the scientist to be the simplest and most acceptable.

Hypotheses chosen as likely to account for data *should* be simple for reasons already stated, and *must* be fairly simple if the data are to be subjected to statistical analysis. Values calculated on simple hypotheses allow a greater degree of variation between hypothetical and observed values. The necessity for this "freedom" between hypothetical and observed values will be explained in the next section. The amount of "freedom" must also be exactly calculable, and this necessitates that the explanatory hypotheses be expressible in mathematical form.

Degrees of Freedom.

The results of the application of statistical analysis to data are meaningless unless the analyst knows exactly what is meant by degrees of freedom and can apply his knowledge without the slightest chance of error.

If in formulating an explanatory hypothesis some restriction is placed upon the possible variation between observed and hypothetical values, this evidently must be allowed for when the extent of the variation is being used in statistical analysis. A restriction is placed upon this variation when any part of the hypothesis is deduced from or even suggested by the observed values. Exact valuation of such restriction is possible, however, only when the part of the hypothesis deduced from the data is calculated mathematically from them. This is most readily explained by way of a diagram on which points representing the values of a variate measured on a co-ordinate axis are set opposite the corresponding values of another on another co-ordinate axis, as in ordinary graphs. Fig. 1 shows such a diagram, on which the variates are termed x and y.

In Fig. 1 there are three points of the kind mentioned.

Let us suppose now that our hypothesis is that the three points lie on a straight line, that is to say, a straight line of any kind whatever — lying of course in the plane of the points. It is evident that the line may be at an infinite distance from *all* the points, that is to say, there are three degrees of complete freedom in variation of the points from the line. Let us now draw a line through the mean of the y-values. This postulates that the sum of the vertical distances of the points from the line, reckoned as positive upwards and as negative downwards, is equal to zero. It is evident that the line is fixed in

position. It is parallel to the x-axis and has been made to pass through the mean (m) of y. In fact its equation is

$$y = m.$$

From such a line it is clear that two of the points may be made to vary in any way, *provided that the third point is adjusted to keep the sum of the distances constant.* The third point has no freedom at all, one degree of freedom is completely absorbed by making the line pass through the mean of y.

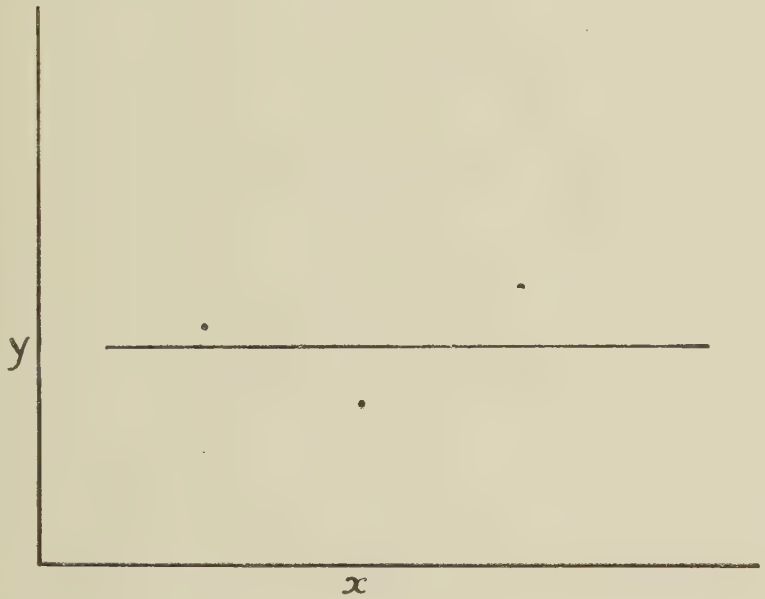

Fig. 1.

Let us now draw a sloping straight line to represent our hypothesis, the equation being

$$y = m + bx.$$

Calculation of b from the data postulates that the sum of the moments, of the y-values considered as weights, about the mean of x is kept constant. Such a line is fixed both in position and slope. Is is evident that the distance of one of the points from the line may be varied to any extent provided that *both* the others are adjusted to keep constant both the sum of the distances and the sum of the moments. The latter sum which contains the variable x is *independent* of the first which does not contain x. Only one degree of freedom remains, two have been absorbed in the calculation of m and b.

If the equation to the hypothesis is

$$y = m + bx + cx^2$$

and m, b, and c are all calculated from the data, there are three independent restrictions of variation between hypothesis and observations. No degrees of freedom remain, and the line will pass through *all* the points.

It is a general statistical rule that a degree of freedom is absorbed from possible variation of observations from a value or set of values given by a hypothesis, for each independent constant pertaining to the mathematical expression of the hypothesis which is calculated from the data.

The reason why it is desirable that hypotheses should be simple and expressible mathematically is now plain. The simpler the hypothesis the fewer degrees of freedom are absorbed. If the hypothesis is not expressible mathematically it is impossible to evaluate the loss of freedom in the variation caused by adjustment between hypothesis and observations. For instance, a freehand curve may be drawn roughly to represent the three points in Fig. 1. The mere fact that drawing the curve is *influenced* by the positions of the points means that freedom in variation of points from curve is restricted. It is, however, impossible to evaluate the restriction. Statistical analysis is impossible unless a certain *definite* fraction of total variation is completely free from restriction, for the reason that the estimation of the likelihood that the variation is due to chance depends entirely on such freedom.

For statistical analysis to be possible it must be ensured either that hypotheses to explain data are expressible mathematically and are calculated from or adjusted to the data in the most efficient manner possible, or that the hypotheses are entirely free from influence by the data. The data considered are numbers, and it is necessary only that the hypotheses are free from influence of the numbers themselves, or are calculated from them.

As a general rule data must be examined partly by "free", partly by "bound" or calculated hypotheses. In statistical analysis it is usually necessary to divide the numbers into sets or classes, but such division must not be allowed to be influenced in any way by the numbers themselves. It must be carried out entirely through some extraneous idea. There are exceptions to this rule, however. If the division in being influenced by the numbers absorbs a *known* number of degrees of freedom from their variation, the division is allowable.

One is strongly tempted in fishery work to allow data to influence their division in terms of space. For instance, it seems a useful and sensible thing to draw irregular contours on a chart, to divide sets of higher from sets of lower numbers. This procedure is no doubt useful and sensible. It destroys, however, all chance of testing statistically the reality of the differences between contoured numbers. An irregular contour removes a quite unknown number of degrees of freedom from the variation of the numbers in contoured areas.

It should be possible in the future to devise a method whereby simple contours of known mathematical form may be calculated from the data so as to give the greatest possible "area effect" or difference between the numbers on one side of a contour and on the other. Such contours or dividing lines would absorb known numbers of degrees of freedom and the value of the lines as divisions could then be tested statistically. I do not think the problem is an easy one to solve. Until it is solved, and if it is desired to test data statistically for area effect, area divisions must not be influenced in any way by the numbers forming our observations. It is perfectly allowable to be influenced as much as we like by the *positions* of our observations regarded as mere dots on a chart or by any other conditions related to our data. For instance, a chart may be contoured for salinity, numbers of fish eggs contoured by the salinity contours, and salinity effect on egg-distribution tested statistically.

The Processes of Statistical Analysis.

A particular explanation or a set of explanations for data is chosen as being reasonable and these explanations or hypotheses are subjected to tests to decide whether the data themselves show the hypotheses as unlikely to be true. To every hypothesis there is an opposite hypothesis. In many cases the hypothesis opposite to that under test is the more explanatory of the two. The hypothesis under test is called the Null Hypothesis. So long as the null hypothesis is quite possible *a priori*, it does not matter how unlikely the data *appear* to show it to be. The tests are not invalidated by this.

All statistical tests depend on the comparison between some kind of function, A, of the tested data and the same kind of function, B, of such data as would be obtained if the null hypothesis were true. The function of the data tested, A, is always a measure of divergence of the observed from the hypothetical data. The question to be answered by the comparison is, In what percentage of cases would so great a measure of divergence as A arise by chance if the null hypothesis were true? To answer this it is necessary to know, or to be able to calculate, the distribution in random samples of the function B of the hypothetical data. Given this knowledge the question can be answered immediately. Statisticians are nearly always more interested in the disproof of the null hypothesis than in its proof. Very rightly, therefore, they give the null hypothesis ample opportunity not to be proved wrong, by considering its unlikelihood of being true not *significant* unless so great a divergence as that measured by A has a very small chance of being found in a random sample. The "level of significance" usually employed in statistical tests is $P < .05$. This implies that a divergence as great as that measured by A occurs by chance in only one in twenty random samples such as would be obtained if the null hypothesis were true. We therefore consider the null hypothesis to be disproved by the data, though it should be remembered that it is not definitely disproved but merely shown to be

very unlikely to be true. It must be accepted as a fact that we can be misled occasionally by data even if statistical tests are applied. Such occasions are, however, minimized by the use of these tests.

It is a general rule among statisticians to consider the null hypothesis acceptable if not proved by data to be unlikely to be true. I am not in agreement with this procedure. I consider that before such acceptance takes place, and quite apart from *a priori* considerations of the likelihood of the null hypothesis, the reverse hypothesis should be given the benefit of the doubt, as in the opposite case the null hypothesis was given the benefit of the doubt. Cases rarely arise, however, in which this difficult question need be considered.

The statistical function (A) calculated from the data takes many forms, among these being the following: the linear regression coefficient (b), the correlation coefficient (r), the difference between the means of two samples ($m_1 - m_2$), the mean divided by its standard error (t) a measure of deviation from the mean in terms of the mean (χ^2), a measure of the difference between the variances of two samples (z), and a measure of the difference in form between two samples or between a sample and a hypothetical population (χ^2).

If the null hypothesis were true in all its various forms the real values of all the above functions would be zero. This should define sufficiently what is meant by the phrase. The numerical *values* of the functions A — their differences from zero — are assumed to have arisen *entirely* from the error due to random sampling; they are due to the fact that the whole population of numbers from which ours are samples was not examined. As an instance of the meaning of the null hypothesis it may be mentioned that testing the significance of a difference between two means is really testing the likelihood of the hypothesis that there is no difference between them.

Statistical Specification.

The null hypothesis, without which it is impossible to apply statistical tests to data, postulates the assumption of a population of a particular distribution form. From this population our sample is assumed to be drawn. In some cases, the hypothetical population is regarded as being completely defined by one or more samples in our possession. In other cases, the "best-fitting" distribution of a particular mathematical form is taken to be the parent distribution. Until the parent distribution is specified, it is impossible to examine the random sampling distribution of the particular function to be employed, t, r, or z, say, to see whether the value of the corresponding statistic calculated from our sample or samples is likely to have arisen by chance from the assumed parent.

Sometimes the form of the parent distribution is fixed by the very nature of the case. For instance, it may be of interest to find out whether in many samples of a species of fish of different ages, males and females occur in equal numbers, within errors of ramdom sampling. In this case the null hypothesis that there is no significant divergence

from equality in numbers of each sex in the various samples is perhaps more "explanatory" than the reverse hypothesis. It is certainly acceptable if not negatived by the data themselves. The form of the parent distribution and its parameters are fixed by the null hypothesis as a binomial distribution, in the mathematical expression for which p, the chance of a male, $=\frac{1}{2}$, q, the chance of a female, $=\frac{1}{2}$, and n is the number of samples. Another case of interest, in which the form of the hypothetical parent distribution is fixed by the nature of the case is the enquiry whether a planktonic species is uniformly distributed in the water. In this case the numbers of the species, in samples taken by an instrument which is practically free from instrumental error, will vary in accordance with the Poisson series. A case in which the form of the hypothetical distribution is fixed but in which the parameters are ambiguous is the following. A large number of a species of fish of the same size and age are kept in a tank under controlled conditions which are the same for all. The reasonable null hypothesis that variations in growth of the fish are due merely to the influence of chance in the feeding of the fish would produce a distribution of lengths which would be binomial were it not for the fact that length is a continuous variate. The normal error distribution might be the expected parent distribution in this case. Since, however, growth probably influences further growth, it is probable that the Galton-Macalister distribution would be the more likely to be the parent. In this distribution it is infinitesimally small percentage increments of growth in which there is a chance element. If this is the distribution to be expected the logarithms of the total lengths of the fish after growth would "fit" the normal distribution, if there were an infinite number of fish in the sample.

The fact that such continuous distributions as the normal and the Galton-Macalister extend to infinity in one or in both directions need not worry us. They do this only if the sample is infinite. The two impossibilities of infinite extension and infinity of sample cancel each other, so to speak. A fish, however, cannot have zero length (let alone minus infinity!), and clearly the growth of an inch in a fish of half an inch is an entirely different thing from this growth in a fish of ten inches. Thus the Galton-Macalister would appear to take the place of the normal as the distribution proper to fish lengths and lengths of all other growing things which have grown up under homogeneous conditions.

Often we have no preconceived ideas as to the origin of a sample, no knowledge to guide us in our choice of a hypothetical parent distribution. In such cases I believe it safest and most reasonable to consider that the parent is exactly like the sample in form. This is the only hypothesis which the sample itself shows to be even possible. It is most unlikely, certainly, but this is better than possibly impossible. If we have more than one sample it is safest to assume that their aggregate gives the form of the distribution. It is true that allowance has not been made for chance in the genesis of the sample. It is, how-

ever, quite impossible to allow for chance here. We do the best we can and choose a parent distribution which will give the sample or samples more often proportionately than would a single distribution of any other form whatever. It is true that the sample is infinitely more likely to have been drawn from *one or other* of an infinity of populations something like it than from one exactly like it, but we must choose one and we choose the best. The exact specification of the parent distribution will be seen later to have little importance in practical statistics, but it is important to demonstrate that the good statistician is always guided by common sense in making his assumptions.

Very often the statistician makes the assumption that the hypothetical parent distribution is exactly like the sample, proceeding then to *use* for testing purposes a distribution which is not very like the sample. It may be that the used distribution is not even a *likely* parent of the sample, and would not produce it nearly as often proportionately as would thousands of others. Is he justified in doing this? The answer is, Yes, if the random sampling distribution of the function to be used in the test is very similar in the used and in the assumed parent distribution, the latter being exactly like the sample.

The *used* parent distribution is almost always the normal, the Galton-Macalister, the binomial, Pearson's Type III, or the Poisson series. The reason for this is a common-sense reason. The random sampling distributions of some or all of the testing functions or criteria are known and have been tabulated in the normal, binomial, and Poisson series. Frequencies which fit the other two distributions mentioned may be reduced to the normal by taking the logarithms or the square roots of the observations respectively. There are few other distributions in which the distributions of the criteria are known and have been tabulated and there are other reasons also which make these most troublesome and tedious in use.

When the t-distribution, the z-distribution, the distribution of the difference between two means, etc. are spoken of, the distribution of these functions in random samples from a normal population is always meant.

Our only concern, if we wish to apply "normal" theory to our sample, is to find out whether the assumed and the used distributions are sufficiently alike. There is no single criterion of sufficient likeness, but there are tests for significant unlikeness of different kinds. These are very simple to use and will be discussed later.

Statistical Estimation.

It has been pointed out that hypothetical distributions used in statistical tests are used in two radically different ways. In the first a hypothetical distribution forms a part of the null hypothesis, in the second it is substituted for the actual null hypothesis for practical reasons. In both cases it is usually only the mathematical form of the

hypothetical parent population which is given by the null hypothesis or is assumed. We still have to find the particular distribution of the given form which would be the most likely to yield our sample as a random sample. This is done by assuming that our sample *is* a random sample from the "best-fitting" distribution of the given form, the assumption that functions of our sample frequencies are *estimates* of the corresponding functions of the proportional frequencies in the assumed parent distribution following as a matter of course. These functions of the parent frequencies are called parameters, those of the sample frequencies are called statistics. It should be remembered always that the statistics are not identical with the parameters but are estimates of them. A statistic is usually denoted by a Roman, the parameter of which it is the estimate by a Greek letter.

It is of great importance that a statistic should be calculated by a method which makes it a *consistent* and an *efficient* estimate of the corresponding parameter. If this is not ensured, the hypothetical distribution does not truly conform to the null hypothesis, nor is it an efficient practical substitute for the real hypothetical distribution when such substitution is made for practical reasons. A consistent statistic is such that it tends to equality with the parameter as the sample is increased, becoming identical with it with an infinite sample. An efficient statistic has a small spread in random samples; its standard error is small. There is a method universally applicable for calculating statistics which results always in their being consistent and of the maximum efficiency attainable in practice. It is known as the Method of Maximum Likelihood and its development is due to R. A. Fisher.

The Method of Maximum Likelihood.

Let us assume that our sample consists of measurements (of a species of fish) in centimetre class-intervals. The hypothetical parent population is then considered also as being divided into the same class-intervals. If the class interval $x_n - x_{n-1}$ in the assumed parent population contains the fraction p_{n-1} of the whole population, this is the probability of any one measurement in the sample falling in this class-interval. The probability of y_1 measurements between x_n and x_{n-1} in a series of y_1 trials is $(p_{n-1})^{y_1}$. If the proportional frequencies in the parent population in class intervals $x_2 - x_1$, $x_3 - x_2$ and so on are p_1, p_2, etc. respectively the combined probability of y_0 fish of $x_1 - x_0$, y_1 fish of $x_2 - x_1$ cm., y_2 fish of $x_3 - x_2$ cm. and so on in a series of $y_0 + y_1 + y_2 + \ldots$ trials is given by

$$p_0^{y_0} p_1^{y_1} p_2^{y_2} \ldots\ldots\ldots\ldots p_n^{y_n},$$

which is generally written

$$\Pi_o^n (p)^y.$$

Taking logarithms of the factors we have for the logarithm of the combined probability

$$y_0 \log p_0 + y_1 \log p_1 + y_2 \log p_2 + \ldots\ldots\ldots\ldots y_n \log p_n$$

$$\text{or } S_o^n y \log p.$$

The combined probability

$$\Pi_o^n p^y$$

is termed the Likelihood of the parent population. It is not the probability that the assumed *is* the actual parent population, but is the probability that *if* the assumed were the actual parent, our sample would be drawn[1]). If the assumed parent population be assumed to have a given mathematical form then it is common sense to stipulate that the parent must be the population of the given form which would give rise to our sample in a higher percentage of cases than would any other *of the same mathematical form.* Parent populations of other forms are not considered. The actual, not the mathematical, form of the parent population may be varied by varying the values of the parameters in the mathematical expression for the population. We therefore have to vary these parameters until the Likelihood of the parent is a maximum. The determination of the values of the parameters which make the Likelihood a maximum is carried out by partial differentiation of the logarithm of the Likelihood with regard to each parameter. The resulting equations are sometimes directly soluble, but often have to be solved by methods of continued approximation.

The method of maximum Likelihood would appear to be the only common-sense method of fitting hypothetical curves or distributions to observation. Fortunately, its solutions show that the methods always employed for fitting the normal distribution, the Poisson series, and the binomial distribution are correct, as are also those used for fitting regression lines of the form

$$y = a + bx + cx^2 + \ldots.$$

and of the harmonic form. The method of moments as used for fitting some of the Pearsonian curves does not, however, give the maximum likelihood solution.

The Method of Least Squares.

Very often the solution given by the method of maximum Likelihood agrees with that given by the method of least squares. The mathematical processes involved in both methods are often identical. According to the method of least squares, the parameters of the hypothetical distribution or regression line are calculated so that they

[1]) The method of sampling is assumed to be such as would yield *on the average* a total sample of $y_0 + y_1 + y_2 + \ldots.$ fish. It is not merely the measuring of a given number of fish. The theory will be explained more fully in the second part of this paper.

make the sum of the squares of the deviations of observed from hypothetical numbers a minimum. The squares of the deviations are used for two reasons. Firstly it is impossible to *minimize* the actual deviations since some are negative, others are positive, and the result would be to make their sum equal to minus infinity! Secondly, sums of squares of deviations, that is to say, weighted variances, are additive, and the result of minimizing these is to give a minimum total variance of observed about calculated values. The parameters calculated in this way have therefore the lowest possible standard error. This is evidently desirable.

As an illustration of the method of least squares, we may take the fitting of a regression line $y = a + bx$ to a series of observations Y arranged as the dependent variate on x the independent. We have to minimize

$$S(a + bx - Y)^2$$

for variation in a and b.

We write then

$$\frac{\partial}{\partial a} S(a + bx - Y)^2 = 0$$

$$\frac{\partial}{\partial b} S(a + bx - Y)^2 = 0.$$

Differentiating with regard to a, we have

$$S(a + bx - Y) = 0$$

and, with regard to b

$$Sx(a + bx - Y) = 0.$$

Thus

$$Sa + bSx = S(Y)$$
$$aSx + bS(x^2) = SxY$$

We may write $Sa = na$, where n is the number of observations, and, since all the sums are known, the equations are immediately soluble for a and b.

(To be concluded)

Modern Theory of Exploiting a Fishery, and Application to North Sea Trawling.

By

Michael Graham,
Fisheries Laboratory, Lowestoft.

THERE have recently been three important papers on the theory of most effective fishing. Russell's of 1931[1]) laid the theoretical foundation. Hjort, Jahn and Ottestad[2]), in 1933, detected the significance of the point of inflexion in a sigmoid population curve. To Thompson and Bell, 1934[3]), belongs the credit for emphasizing the importance of the rate of fishing, from which follows the peculiar attraction of the modern theory, that the benefit of efficient exploitation lies more in *economy of effort* than in increase of yield, or preservation of future stocks, though both of these purposes may also be served. Thus Thompson and Bell's argument has been put into practice, and has in fact led to a progressive economy of effort during three years, in which the yield of the Pacific halibut has been artificially stabilized at a somewhat low level, which it had reached during the depression of 1931[4]). Their theory, however, is incomplete. The present work has had a double aim, that of correcting and continuing the theory, and of applying it to the North Sea fisheries.

There are three ways of approaching the problem. They all use data, different data in each case, and they all lead to the same conclusion, that an economy of effort is desirable in the North Sea, that is, *that a certain proportion of the time and money of the fishermen is at present devoted to reducing their catch, or is at least wasted.* It also follows that in unrestricted fishing, proceeding as it usually does at ever increasing intensity, as grounds and habits become better and better known and gear more and more improved, there must come a time when new inventions are harmful. Nevertheless, once the new

[1]) Journ. Cons. Int. Expl. de la Mer. VI. Copenhagen.
[2]) Hvalrådets Skr. 7. Oslo.
[3]) Rep. Int. Fish. Comm. 8. Seattle.
[4]) *Loc. cit.* p. 12.

invention has done its harm in reducing the productivity of the stock, its use must be continued, because the old gear will not pay expenses on the less productive stock. So the fishermen are left with the expense of the invention, with no compensating increase in yield.

It is tempting to suggest practical ways of making the improvement in exploitation, because the peculiar virtue of the modern theory is that the measures needed involve Economy and Leisure, both of which are intrinsically good, whereas measures we have thought of before were devoid of any attraction in themselves. However, it would be altogether premature to discuss practical measures, whilst the theory and evidence of its applicability have not stood the test of criticism.

If the theory is sound there are many practical implications, but they are not the concern of this paper.

The essentials of the theory are two. **A.** If the rate of mortality be reduced, as by reducing the rate of fishing (hence increasing economy and leisure), the average age of the population will be raised, and *vice versa.* **B.** There is a most profitable age to harvest any growing crop. For example, the hay crop, of species maturing in different weeks, must yet be cut at a certain age which takes advantage of as much growth as possible and avoids as much "mortality" by seeding as possible. The pasture should carry only a certain number of sheep, neither too many nor too few for the best yield; that is, there is an optimum rate of cropping. A growing steer must theoretically be sold at a certain most profitable age, depending on rate of growth and rate of food consumption.[1]) It should be noted that none of these cases takes account of the necessity of leaving sufficient adults for reproduction, with which indeed this paper does not deal, except inclusively under (3) below. But we note that anything we do for better exploitation in the North Sea should be helpful also as regards reproduction.

It follows from these two considerations, A and B, that all we have to do, to be satisfied that economy and leisure are available, is to demonstrate that the present age of our stock is below the most profitable age. Actually it seems that, near its maximum, the yield of the North Sea is comparatively stable for quite considerable changes in rate; it is expressed by a rather flattish topped curve, and it is therefore most practical to say that it will pay to reduce fishing so long as the yield is not thereby reduced. Also, the maximum yield is not exactly the most profitable. Some further economy can still be made by reducing fishing, depending on the ratio of overhead costs (requiring a certain turnover) to running costs per ton of fish.

We shall now apply the theory enunciated in A and B, above, to the North Sea Fisheries, in three independent ways.

Our three solutions use varying amounts of the theory, and each has its share of approximations and assumptions. No. 2 seems the best founded.

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[1]) James Wilson. The Principles of Stockfeeding. London 1927.

1. Evidence of General Statistics.

In this section we take it as an accepted fact that the stock in 1928—1932 consisted of smaller fish than in 1909—1913. There are statistics which support this, but they are open to some objection and I prefer to take this fact to be generally admitted. Now, we find that the total yield in 1909—1913 was fully as great as in 1928—1932. But, if the fish were larger, then it is legitimate to think that they were older; so an older stock gave, for five years within which we know of no great change in fishing rate, as great a yield as did a younger stock for another five years, within which we also know of no great change in fishing intensity. We use the landings of all North Sea species, except herring, by all fishermen, in metric tons (000 omitted)[1]):

1909—1913:	419,	416,	440,	463,	433.	Mean: 434
1928—1932:	413,	431,	458,	428,	411.	Mean: 428

Actually the *catchés* in the earlier period were certainly higher than in the later, because fish were then rejected at sea which are now landed. The evidence of these figures simply is that the catch *was* no less before the introduction of the Vigneron-Dahl trawl and other changes of which the nett result has been to lower the age of the stocks.

So far as it goes, the evidence of general statistics is, therefore, that the yield would not be less if the stock were stabilized at a lower fishing rate.

2. From Growth and Age-Census Data.

a. Argument.

According to Russell's equation a stock will be in equilibrium with fishing when the "logarithmic" rates (r in compound interest equations, such as $w_2 = w_1.e^{rt}$) tending to increase it are equal to those tending to decrease it, or

$C = A + G - M$ where C is capture,
A is recruitment,
G is growth,
M is natural mortality;

say

$C = V$, calling V the "rate of natural increase." ..... (1)

Consider a stock N_1W_1, where N stands for number and W for average weight, becoming N_2W_2 at a year older.

Then

$$N_2W_2 = e^{V}N_1W_1 \quad \text{..... (2)}$$

Now, in equilibrium, the yield is Y in

$Y = NWC$
$= NWV$

[1]) Bulls. Stats. Cons. Int. Copenhagen.

So

$$\frac{Y_2}{Y_1} = \frac{N_2 W_2 C_2}{N_1 W_1 C_1} = \frac{e^{V} N_1 W_1 V_2}{N_1 W_1 V_1} = \frac{e^{V} V_2}{V_1} \quad \ldots\ldots\ldots (3)$$

So

$Y_2 - Y_1$ will be positive

so long as

$e^{V} V_2 - V_1$ is positive

or, *a fortiori,* since V_1, V and V_2 must be in descending order of magnitude, as

$e^{V_2} V_2 - V_1$ is positive,

which, expanding e^{V_2}, discarding minor necessarily positive terms, substituting the constituents of V, and putting in numerical values for A and G from the data (which will be described later) reduces, for the North Sea cod, to the statement that

$Y_2 - Y_1$ will be positive, so long as

0.456 at least equals $(M_2 - M_1) + 1.516\ M_2 - M_2^2$ ..... (4)

in which $(M_2 - M_1)$ and M_2 are considered to be unknown.

If we put in trial values for these unknowns we find graphically that either the change in natural mortality rate or the new natural mortality rate has to be quite ridiculous, from the information we have, for the right half of equation (4) to be equal to 0.456. We therefore conclude that there is no doubt that the new yield will at least equal the old, and that there is plenty of margin for error in the approximations we have used as to A and G. The values obtained are as follows.

If $M_2 - M_1$ were (%)	M_2 would have to exceed (%)
40	3
30	11
20	19
10	29
0	41

Now, from our census data, we know that we are only proposing to raise the average age from $2^1/_2$ to $3^1/_2$, in a fish which is first mature at about 5 years of age, and it is really very unlikely that in these young fish the natural mortality rate would thereby be raised. In fact we would expect it to fall. Yet if we make the change only zero, we find that the new mortality rate has to be as high as 41 per cent., which is quite impossible from what information we have, and even from consideration of the natural span of life, which is about 8 years even under fishing, and likely to be about 20 without fishing. But if we make M_2 something reasonable, as 11 per cent. or less, we would have to believe that the change was positive by the absurd amount of 30 per cent. or more. We see from inspection that continuation

of the series of the trial values in either direction can only result in more ridiculous values, either of one unknown or the other.

Similar results are obtained from the data on North Sea haddock and plaice. The three species, cod, haddock, and plaice, together make up more than 60 per cent. of the North Sea trawl catch, whether by weight or value[1]). There is no reason to believe that the other species would show compensating changes, sufficient to prevent the conclusion applying to the total. It is therefore concluded that the yield would be no less, were the fishing effort reduced so as to allow the fish to become one year older.

b. Data and Approximations.

The data have all been published elsewhere. For the cod I have used those of this laboratory[1a]), the haddock data are from the work of Harold Thompson of the Scottish investigations[2]). For the plaice we use Bückmann's data[3]). The general method was to calculate "logarithmic" rates of growth at various ages by applying the compound interest law to the data given. Where interpolation was necessary this was done graphically. It is hoped that the footnotes will enable the computations to be repeated. Table 1 is the calculation sheet for the cod, using the census of September[4]). Another, using the annual census, gives similar results. Little letters are used for rates, etc. at a given age.

Table 1.

	Age 1½	2½	3½	4½	5½	6½	7½	Total
g	1.89	1.01	0.60	0.44	0.39	0.29		
w[5])	250	950	2000	3350	5010	7180		
wg	472	960	1200	1474	1954	2082		
n_1[6])	47	32	8	9	3	1	1	$101 = N_1$
$n_1wg/100$	222	307	96	133	59	21		$838 = N_1W_1G_1$
$n_1w/100$	118	304	160	302	150	72		$1106 = N_1W_1$
								$\therefore G_1 = 0.758$
								$A_1 = 118/1106$
								$= 0.107$
m	0.20	0.13	0.08	0.05	0.05	0.05		
n_2[7])	478)	40	29	8	9	3		$136 = N_2$
$n_2wg/100$	222	384	348	118	176	62		$1310 = N_2W_2G_2$
$n_2w/100$	118	380	580	268	451	215		$2012 = N_2W_2$
								$\therefore G_2 = 0.651$

[1]) Bull. Stat. 1932 (1934) p. 18 Mean 1912—1932.

[1a]) Graham, Sea Fish. Invest. XIII. 4. London 1934.

[2]) Rapp. Cons. Int. LIV. Copenhagen 1929.

[3]) Rapp. Cons. Int. LXXX. Copenhagen 1932.

[4]) Graham 1934, p. 139.

[5]) By interpolation. Weights at whole years from Graham, 1934, p. 137, March, and Russell, Sea Fish. Invest. V. 1. 1922. p. 75. Also, for age 1, length from Graham 1934, pp. 42 and 67, and weight from Russell, 1922, by integrating length cubed with respect to length from average length at 0 to average length at 1 year old and so on, and multiplying by a condition factor. A simpler method would have served for the present purpose.

Lines g, w and n_1 are from the data. The calculation as far as G_1 is simple multiplication, addition and division. The line m requires explanation. Strictly speaking we only know the order of magnitude of the natural mortality rate, not any values as accurate as those given. We do, however, only use these values for weights in the calculation of G_2, and we rely on the experience that errors in weights are of minor importance in calculating an average. As to our knowledge of the order of magnitude, we have the total mortality rate for haddock from Thompson's census of age[1]), and we have the fishing mortality rate for plaice from large-scale marking experiments. Thus Borley reported that something like 30 per cent. per annum of marketable plaice were returned in the years before the war[2]). If we subtract fishing mortality rate from total mortality rate we are left with natural mortality rate. With these data in mind, I have simply written in some probable values for cod. The remainder of the calculation can be followed from the notes, but there are two more approximations that should be pointed out. Firstly it has been assumed that the same number of recruits would be found in the line n_2. Secondly, it has been taken as a first approximation that g and w would be unchanged in the older stock. It will be remembered that the defence of these approximations is that there is ample room in the final conclusion for error that they may have introduced[3]).

The conclusion of this digest of the results of fishery research is also that a lower fishing rate would give as great a yield, when the stock became stabilized at that rate.

3. From Consideration of the Effect of the War on Landings.

(i) The principal assumption of this section is that V, the "logarithmic" rate of natural increase of the stock at a given moment, including rate of reproduction, is directly proportional to the difference between the weight of the stock at that moment and the maximum weight the area will support. We can be pretty sure that V is some positive function of that difference in weight, but the assumption of direct proportion may, of course, be too simple. It is, however, a reasonable first approximation.

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[6]) Graham 1934, p. 139.

[7]) $n_2 = n_1 . e^{-r}$, where r is the assumed rate of natural mortality at a given age in whole years.

[8]) Assuming new entry unchanged.

[1]) *loc. cit.* p. 157.

[2]) Sea Fish. Invest. III. 3. London 1916. p. 66.

[3]) Some further notes will be necessary for repeating the calculations for cod (annual census), for haddock and for plaice. In the cod calculation it was necessary arbitrarily to repeat n_2 at 2½, owing to disturbance by net selection. It can be shown for all three species, that disregard of net selection has probably caused an underestimate. For haddock I used Thompson, 1929, p. 146, and Russell, Sea Fish. Invest. I, 1914, Pt. I, p. 130 and integrated. For plaice I used Bückmann's figures, p. 13. Stock A.

(ii) From the *Bulletins Statistiques* we can express the landings of all bottom species (that is excluding herring) as percentages of the average of 1909—1913. We obtain

1919	1920	1921	1922	1923	1924	1925
105	128	115	117	88	89	100

That is, the drain of 1920—1922, namely 28, 15 and 17 per cent. above the pre-war average could not be sustained, although the stock was augmented by the war respite.

(iii) We have unpublished figures for the landing in each month by 1st class British steam trawlers landing their own catch in England. We also have the corresponding number of days absence. The earliest period in 1919 in which the number of days absence approached the pre-war figure was at the end of the year, from October to December. The data are

	Days absence (00 omitted)		Landing (cwts; 000 omitted)	
	1913	1919	1913	1919
Oct.	137	106	177	348
Nov.	119	100	162	266
Dec.	131	113	172	262
Total	387	319	511	876

These figures are not accurate indices of the relative weights of the stock, but they can be used as a rough guide. Thus 876/511 is 1.71. Alternatively, (876/319): (511/387) is 2.08. We conclude that the stock at the end of 1919 was rather less than double the weight of the pre-war stock.

(iv) From (iii) we make the assumption that the upper limit of stock is not less than twice the pre-war weight.

(v) We have all in our minds the idea that the stocks had considerable respite during the war. I try to estimate this by saying that it was equivalent to so much time of complete cessation of fishing. The working has to be crude. Foreign fishing was not so much curtailed as English fishing. Also English fishing was more curtailed than the number of days absence indicates. The statistics are:

	1913	1914	1915	1916	1917	1918	1919
Eng. days absence (000 omitted) ..	147	124	76	41	37	56	92

Because of information collected soon after the end of the war as to war-time interference with even the reduced fishing, I think a more comparable series would be as follows.

Corrected Eng. days absence	147	120	60	30	30	50	85

(This correction is not necessary to the conclusion).
If we multiply each of these figures by the corresponding ratio of the

total landing to the English landing, we obtain another series, which seems the best we can achieve, as an index of intensity of fishing.

	1913	1914	1915	1916	1917	1918	1919
Relative intensity	346	335	191	157	109	141	230

Finally, I call the respite of 1914 $\frac{346—335}{346}$ of a year, and so on. Adding up the series of such fractions we obtain about two and two-thirds years. This gives some numerical idea of how much respite the fish had, but obviously one wishes it were better.

(vi) Knowing that many marks are shed or not sent in, we use the information from B o r l e y[1]) to assume that the pre-war rate of natural increase (equals fishing rate in a stable stock) was more than 30 but distinctly less than 50 per cent. per annum in 1913 and is 50 per cent. now.

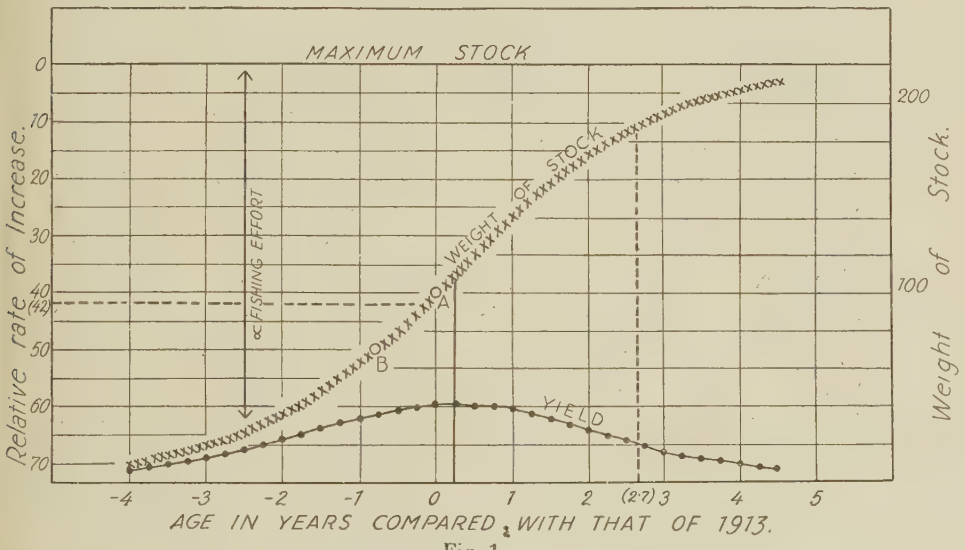

Fig. 1.

(vii) Under (1) we have seen that the landing of recent years is hardly less than in 1909—1913, the difference in catches being only what we can allow for rejected fish in pre-war days. So we assume that the pre-war catch was not more than 20 per cent. greater than the present catch.

Thus Fig. 1 was drawn. Starting at A with stock of weight 100 we chose a rate of 40 per cent. per annum and a maximum stock of 220. One tenth of the chosen rate was applied at simple interest to give the stock one tenth of a year later. The rate was then changed in proportion to the new vertical distance from the maximum and the

[1]) *loc. cit.*

next point was found. So proceeding upwards and downwards the whole curve of weight of stock was drawn. It clearly resembles the sigmoid curves of Hjort, Jahn and Ottestad and of earlier writers. Judging by the difficulty encountered in drawing the trial attempts at Fig. 1, very little latitude has been introduced by the graphical method. This is the only curve encountered that would fulfil the numbered requirements already given.

Fig. 1 gives a complete representation of the theory, although, as we have been at some pains to show in our arrangement of this paper, the basis for action does not rest alone on the fundamental assumption as to rate of increase. The main curve AB in the figure traces the natural growth of a stock, starting from a low value and not subject to fishing. At any point the stock may be stabilized by a fishing effort which is proportional to the vertical distance between the point on the curve and the maximum. The yield under the condition of stability is given by the lower curve, of which the ordinates are differential coefficients of the stock function, that is, they measure the slope of the main curve.

Taking the stock at A as the pre-war stock and that at B as the present stock and numbering the conclusions of the curve according to the requirements, we have:

(ii) that the maximum stable catch is only a little above that of the stock at A, so that the drain of 1920—1933 could not be maintained.

(iii) and (v) that the stock increased to 1.9 times its pre-war weight in 2.7 years.

(iv) that the maximum stock is 2.2 times the pre-war, or about 3 times the present stock.

(vi) that the pre-war rate was 40 per cent. per annum.

(vii) that the pre-war stock could maintain a catch 14 per cent. greater than could the present stock.

These fulfil the requirements.

If we accept these calculations as a rough approximation, we find that the maximum stable yield is 15 per cent. greater than the present yield and that this yield would be obtained by 75 per cent. of the present effort.

Such as it is then, the estimate is that about one quarter of the fishermen's time and expense is at present devoted to reducing their catch.

By way of illustration we finally work out what would be the yield in successive years as a result of reducing fishing time by one-sixth. The present rate of natural increase is assumed to be 50 per cent., balanced by a fishing rate of 50 per cent. In the new circumstances the stock would start to increase at 50—42 or 8 per cent. per annum. As the stock increased it would have a new rate of natural increase, less than 50, until finally the weight increased to the amount shown in Fig. 1 for the rate of 42.

The calculation is carried out in steps of one-tenth of a year:

Table 2. Abridged.

Time	Stock	Rate of Increase			Catch 0.042 of Stock
0	70				2.94
		0.50	— 0.42 =	0.08	
0.1	70.5				2.96
				0.08	
0.2	71.0				2.98
				0.08	
0.3	71.5				3.00
		0.49[1]	— 0.42 =	0.07	
0.4	72.0			.	3.02
.	.			.	.
.	.			.	.
.	.			0.07	.
.	.				.
0.9	74.5				3.13
	Yield in 1st year			=	30.35
1.0	75	0.48[1]	— 0.42 =	0.06	3.15
.	.			.	.
.	.			.	.
.	.			0.05	.
.	.				.
1.9	79				3.32
	Yield in 2nd year			=	32.43
	Yield in 3rd year			=	34.13
	Yield in 4th year			=	35.48
	Final yield[1]			=	39.50
	Present yield			=	35.00

Against our saving of about 16 per cent. in coal and some other expenses, we have therefore to debit a loss in turnover of 13½ per cent. in the first year, 7½ per cent. in the 2nd, 2½ per cent. in the 3rd, and thereafter no loss, but finally a gain of 13 per cent.

It is to be noted that growth is assumed to take place equally throughout the year. This is not so. To ensure as little loss in turnover as possible such an operation should begin in March or April.

Statistics of the war-time respite therefore agree with the other two sources of data, in showing that a reduction of fishing-rate would not harm the yield. They also provide an estimate of the benefit.

Conclusion and Acknowledgement.

This paper is an attempt at more precise formulation of the opinion, that has been long held by many fishermen and scientists, that it would pay to give the fish a chance to grow. Most fishermen and some scientists would also add "and a better chance to breed." I am

[1]) From Fig. 1.

particularly indebted to Mr. W o l l a s t o n, among the colleagues who have been so helpful in discussing this paper, for his emphasis on the possibility that the stocks of some species are not in equilibrium with fishing, but, owing to shortage of eggs, may be in a state of decline, a subject which he is investigating further. Much might be written as to pros and cons in this matter, but a decision is hampered by lack of crucial evidence. In this paper it is only necessary to point out: (i) that even a stock declining in numbers can be better fished, from the point of view of economy, leisure, and yield, if the fish are allowed to grow; (ii) that any reduction of fishing rate would slow down the decline; (iii) that, for all we know, a reduction of, say, 16 per cent. in the fishing rate might indeed be sufficient to arrest the decline altogether. Only this should be made clear, that if the stock be in such a state of decline, one must not be too sanguine as to increase of yield over the present yield, but should rather think of it in terms of the yield that would be taken if the fishing rate were not reduced.

Finally, the correction proposed to the theory, as developed by T h o m p s o n and B e l l, may be put into words: It will pay to reduce the fishing rate at any rate so long as the stock will thereby grow in weight sufficiently for the product of the new reduced fishing-rate multiplied by the new augmented stock to be no less than the product of the old higher rate and the old smaller stock.

Untersuchungen über die Zusammensetzung des Meerwassers im Rigaschen Meerbusen und an der lettländischen Küste des Baltischen Meeres.

Von

E. Zarins und **J. Ozolins,**

Laboratorium für Lebensmittelchemie der lettländischen Universität und Laboratorium für Fischerei des Ministeriums für Landwirtschaft.

DAS Wasser des Rigaschen Meerbusens ist noch recht wenig untersucht worden. Prof. Meyer (1924)[1]) und Prof. Putnins[2]) (1928/29) haben an verschiedenen Orten und zu verschiedenen Zeiten die Temperaturen, den Chlor- und Sauerstoffgehalt und die Alkalinität bestimmt. Prof. Strand und V. Ozolins[3]) haben im Jahre 1930 Temperaturmessungen und Chlorbestimmungen unternommen.

Diese Arbeiten geben jedoch nur einen Überblick über einige wenige Bestandteile und über den allgemeinen Salzgehalt des Wassers. Vollständigere Angaben fehlen gänzlich.

Im folgenden soll über Untersuchungen berichtet werden, die einen grösseren Einblick in die im Rigaschen Meerbusen herrschenden Wasserverhältnisse geben und es gestatten, einige allgemeine Schlüsse zu ziehen. Die Terminfahrten, für die uns der Staatsdampfer "Hidrografs" zur Verfügung stand, fanden in den Jahren 1932—1934 statt.

Das Wasser des Rigaschen Meerbusens lenkt schon dadurch die Aufmerksamkeit auf sich, dass es sich wesentlich vom Wasser des offenen Meeres unterscheidet. In ihn münden viele Flüsse, durch deren Süsswasser das salzige Meerwasser stark verdünnt wird; daher enthält das Wasser des Rigaschen Meerbusens nur gegen 5 ‰ Salze, während

das offene Meer gegen 35 $^0/_{00}$ aufweist. Der Unterschied zwischen dem salzigen Meer- und dem süssen Flusswasser besteht bekanntlich nicht nur im verschiedenen Salzgehalt, sondern auch im Verhältnis der einzelnen Salze zu einander.

Ein weiterer Unterschied ist der, dass die Zusammensetzung des Ozeanwassers ziemlich beständig ist, die Zusammensetzung des Süsswassers dagegen recht bedeutend schwanken kann. Wenn man nun in Betracht zieht, dass dem Rigaschen Meerbusen die Insel Ösel vorgelagert ist und zwischen ihr und der lettländischen und estländischen Küste nur zwei enge Meerengen den Zusammenhang mit dem Baltischen Meere vermitteln, so kann man leicht einsehen, dass die grossen Mengen Süsswasser, die ständig zugeführt werden, einen merkbaren Einfluss auf die Zusammensetzung des Wassers ausüben müssen.

Um die Frage zu klären, wurde an den entnommenen Wasserproben eine Reihe von Bestimmungen durchgeführt. Diese erstreckten sich auf die Temperatur, die Wasserstoffionenkonzentration, die Titrations-Alkalinität und den Gehalt an Sauerstoff, an organischen Stoffen, Chlor, Jod, Sulfat, Phosphat, Nitrat, Ammoniak, Kalium, Natrium, Kalzium, Magnesium und Bor. Die Resultate sind in Tabellen niedergelegt, aus denen dann einige Schlüsse gezogen werden.

Die Orte, an denen die Wasserproben entnommen wurden, sind auf der beiliegenden Karte durch kleine Kreise bezeichnet. Die Tiefenabstände betrugen je 10 oder 20 Meter. Zur Probeentnahme wurde ein automatischer Wasserschöpfer nach Witting benutzt. Die Temperaturen wurden mit dem von Richter verbesserten Negretti-Zambraschen Tiefwasser-Thermometer gemessen.

Einige Bestimmungen und Vorarbeiten wurden schon auf dem Dampfer ausgeführt, und zwar 1) die kolorimetrische Bestimmung der Wasserstoffionenkonzentration nach Sörensen[4]), Palitzsch und Buch[5]), 2) die Bindung des Sauerstoffs zur späteren Bestimmung nach Winkler, 3) die Konservierung von Wasserproben zur späteren Bestimmung von Nitrat und Phosphat und 4) die Ausfällung von Sulfat-, Kalzium- und Magnesiumionen zur Ammoniakbestimmung.

Die angewandten Untersuchungsmethoden waren folgende: Jod nach Reith[6]), Sulfat nach Froboese[7]), Phosphat kolorimetrisch nach Denigès — Atkins[8]) unter Benutzung eines Pulfrichschen Photometers, Nitrate und Nitrite kolorimetrisch nach H. W. Harvey[9]).

Ammoniak wurde mit dem Nesslerschen Reagenz bestimmt, und zwar genau nach der Vorschrift von Wattenberg[10]). Als Kolorimeter diente ein Photometer nach Pulfrich.

Chloride wurden nach Mohr bestimmt. Die Einstellung des Titers der Silbernitratlösung geschah mit Normal-Meerwasser nach Knudsen.

Auch die benutzten Büretten und Pipetten entsprachen den Knudsenschen, und waren für 15°, 20°, 25° und 30° geeicht. Ein Teilstrich der Bürette entsprach 0.005 cm.^{3}, so dass die Ablesegenauigkeit etwa 0.001 cm.^{3} betrug. Titriert wird wie folgt: 100 cm.^{3} des zu untersuchenden Wassers werden in einem Messkolben von 500 cm.^{3}

mit destilliertem Wasser bis zur Marke aufgefüllt. 100 cm.³ dieser Mischung werden in ein Jenaer Becherglas von 250 cm.³ hineinpipettiert und mit etwa 0.1 *N* Silbernitrat titriert. Als Indikator gibt man 6 Tropfen einer 8 % Lösung von Kaliumchromat hinzu, die jedoch erst *nach* der Koagulation des Silberchlorids, also kurz vor dem Ende der Titration, zugefügt werden sollen. Vor der Zugabe des Indikators wird der Niederschlag mit einem Glasstabe kräftig aufgerührt, um seine Oberfläche zu vergrössern und ihn von adsorbierten Chloriden zu befreien. Dann titriert man vorsichtig weiter, wobei langsam umzurühren ist. Vor dem Endpunkt nimmt die Flüssigkeit eine schwach gelbbraune Färbung an, die durch kolloidales Silberchromat hervorgerufen wird. Man titriert bis zu einer bräunlichen Endfarbe, die 3—4 Stunden bestehen bleibt.

Kalzium wurde gewichtsanalytisch bestimmt: als Oxalat zweimal gefällt und nach dem Trocknen bei 105° als $CaC_2O_4H_2O$ gewogen.

Vor der Magnesiumbestimmung wurden aus der Wasserprobe Silikate, Eisen und Kalzium wie gewöhnlich abgetrennt. Das Magnesium selbst wurde als Magnesiumammoniumphosphat gefällt und als Pyrophosphat gewogen.

Kalium und Natrium wurden als Chloride gewogen. Die Kaliumbestimmung geschah nach der Chlorplatinat-Methode, da die Perchlorat-Methode zu hohe Resultate ergab.

Um die Menge der organischen Stoffe festzustellen, wurde nach der Vorschrift von Schulze gearbeitet. 100 cm.³ Wasser werden mit 0.01 *N* Kaliumpermanganat in alkalischer Lösung 10 Minuten lang gekocht. Es muss darauf geachtet werden, dass das Kochen möglichst gleichmässig vor sich geht, was am besten durch elektrische Heizung

Tabelle 1.

Einfluss der Salze auf die Resultate der Permanganatmethode bei der Bestimmung der organischen Stoffe.

				cm.³ I	1/100 N II	$KMnO_4$ III	Mittel	$KMnO_4$ mg./l.	Korrektur
100	cm.³	Leitungswasser	.....	1.67	1.62	1.67	1.65	5.21	
„	„	„	plus 1 ‰ S	1.67	1.67	1.62	1.65	5.21	0.00
„	„	„	„ 2 ‰ „	1.83	1.72	1.83	1.77	5.59	0.38
„	„	„	„ 3 ‰ „	1.83	1.93	1.72	1.83	5.78	0.57
„	„	„	„ 4 ‰ „	1.83	1.83	1.83	1.83	5.78	0.57
„	„	„	„ 5 ‰ „	1.83	1.77	1.93	1.84	5.81	0.60
„	„	„	„ 6 ‰ „	1.93	2.04	2.24	2.07	6.54	1.33
„	„	„	„ 7 ‰ „	1.93	2.24	2.13	2.10	6.63	1.42
„	„	„	„ 8 ‰ „	2.19	2.18	2.18	2.18	6.88	1.67
„	„	„	„ 9 ‰ „	2.19	2.23	2.23	2.21	6.98	1.77
„	„	„	„ 10 ‰ „	2.19	2.28	2.28	2.25	7.11	1.90
„	„	„	„ 11 ‰ „	2.24	2.28	2.23	2.25	7.11	1.90
„	„	„	„ 12 ‰ „	2.32	2.28	2.34	2.32	7.33	2.12

zu erreichen ist, und dass bei jeder Probe die gleiche Kochzeit eingehalten wird. Beim Titrieren mit Kaliumpermanganat darf auch nur langsam gerührt werden, bis die schwach rosa Färbung eintritt.

Nun wird bekanntlich die Genauigkeit dieser Methode durch Chloride stark beeinflusst, und daher kann sie, die bei Süsswasser sehr gute Resultate gibt, bei Meerwasser nicht ohne weiteres angewandt werden. Um über die Grösse dieses Einflusses Klarheit zu gewinnen, wurden die organischen Stoffe im Leitungswasser bestimmt, dem zuvor verschiedene Mengen einer Salzmischung aus 4.05 Teilen Natriumchlorid, 0.75 Teilen Magnesiumchlorid und 0.25 Teilen Kaliumsulfat zugesetzt waren. Das Verhältnis der Salze zu einander entspricht dem des Wassers im Rigaschen Meerbusen. Tabelle 1 zeigt die erhaltenen Resultate. Die Zahlen der letzten Spalte wurden dann als Korrekturen berücksichtigt.

Die Titrations-Alkalinität wurde nach H. Wattenberg[11]) bestimmt.

Die Borsäure wurde wie folgt bestimmt. 200 cm.^{3} Wasser, die sich in einem Erlenmeyerkolben aus Jenaer Glas befinden, werden mit 10 cm.^{3} 1/20 *N* Salzsäure versetzt, die Kohlensäure wird durch Kochen, wie es bei Bestimmung der Titrations-Alkalinität nach Wattenberg angegeben ist, vertrieben, der Kolben abgekühlt und der Salzsäure-Überschuss mit 1/20 *N* Natronlauge, die natürlich kohlensäurefrei sein muss, genau neutralisiert, wobei als Indikator 2—3 Tropfen einer Mischung von Bromkresolgrün und Methylrot benutzt werden.

Um nun die Borsäure zu bestimmen, nimmt man eine neue Wasserprobe von 200 cm.^{3}, fügt 10 cm.^{3} 1/20 *N* Salzsäure hinzu, kocht, vertreibt die Kohlensäure, kühlt ab und versetzt mit genau derselben Menge 1/20 *N* Natronlauge, wie vorher. In die auf diese Weise neutralisierte Flüssigkeit kommen nun 1—2 g. neutrales Mannit und 2—3 Tropfen neutrale Phenolphthaleinlösung. Man titriert mit der 1/20 *N* Natronlauge bis zur schwach rosa Färbung. Aus der Menge verbrauchter Lauge lässt sich der Borsäure-Gehalt berechnen.

Die Methode wurde durch Titration reiner Borsäurelösungen genau geprüft.

Die Bikarbonat-Kohlensäure wurde nach der Titrationsalkalinität berechnet, wobei die Borsäure nicht beachtet wurde.

Die Resultate der Untersuchungen sind aus den folgenden Tabellen zu ersehen.

In den Tabellen 2, 3, 4 und 5 sind einige Resultate unserer Untersuchungen niedergelegt. In der ersten Spalte findet man die Tiefen, aus denen die Wasserproben stammen, dann folgen die Temperaturen, die Wasserstoffionenkonzentrationen, die Menge an Sauerstoff, Ammoniak-Stickstoff, Nitrat- und Nitritstickstoff, Phosphat, Jod und organischen Stoffen.

Aus den Zahlen kann man ersehen, dass das Meerwasser nicht einheitlich ist. Doch lässt sich trotzdem eine gewisse Gesetzmässigkeit erkennen, die allerdings aus den späteren Tabellen klarer hervortritt, sich aber auch schon hier deutlich ausdrückt.

Tabelle 2.

m.	t°	pH	O_2 cm.³/l.	NH_4' mg.N/m.³	$NO_3' + NO_2'$ mg.N/m.³	PO_4''' mg.P/m.³	Cl′ g./kg.	S °/₀₀ nach Knudsen	J′ mg./m.³	Organ. Stoffe $KMnO_4$mg./l.
St. 1.	*1932. 11.X*		*57°44′ N.*				*23°52′ E.*	*(Ainazi)*		
0	9.30	8.17	7.87	28	5	3	2.8552	5.1840	8.7	16.14
10	9.10	8.15	7.68	28	5	4	2.8852	5.2378		16.14
20	8.70	8.07	7.63	22	6	5	2.9050	5.2735	8.7	16.14
30	8.60	7.91	7.86	20	6	6	2.9349	5.3275		16.43
40	7.30	7.78	7.35	20	6	6	2.9751	5.4001	8.9	16.06
St. 2.	*1932. 11.X*		*57°26′ N.*				*23°55′ E.*	*(Kurmrags)*		
0	9.50	8.18	7.80	31	6	3	2.8249	5.1289	8.2	16.17
10	9.45	8.16	7.54	31	6	3	2.8249	5.1289		17.03
20	9.40	8.08	7.63	26	7	4	2.8401	5.1564	8.2	16.87
30	9.40	7.88	7.55	26	7	6	2.8401	5.1564		15.35
40	3.20	7.74	7.63	22	7	8	3.2352	5.8695	14.4	16.74
St. 3.	*1932. 13.X*		*57°29′ N.*				*23°16′ E.*	*(Mersrags)*		
0	9.20	8.15	8.06	26	5	5	3.1102	5.6439	16.0	17.69
10	9.20	8.18	7.94	20	5	5	3.1102	5.6439		14.78
20	9.20	8.12	8.07	18	5	7	3.1148	5.6522	16.1	13.99
30	9.05	7.88	7.27	18	6	4	3.1148	5.6522		13.99
40	6.60	7.62	6.34	18	6	2	3.2250	5.8511	18.6	13.80
St. 4.	*1932. 13.X.*		*57°46′.5 N*				*22°07′.5 E.*	*(Irbesche Meerenge)*		
0	9.10	8.19	8.46	24	6	4	3.1140	5.6508	14.8	14.44
10	9.10	8.16	8.18	26	6	4	3.1140	5.6508		15.07
20	10.10	8.10	8.05	20	7	3	3.4247	6.2116		15.07
30	11.20	7.90	7.11	22	7	2	3.7247	6.7531	22.4	15.07
St. 6.	*1932. 1.XI*		*56°11′ N.*				*20°36′ E.*	*(Pape)*		
0	11.15	8.18	7.76	24	6	3	3.8902	7.0518	17.6	11.72
10	11.15	8.16	7.75	24	5	5	3.9051	7.0787		11.72
20	11.15	8.04	7.56	22	5	5	3.9051	7.0787		11.72
30	11.10	7.86	7.55	22	6	7	3.9051	7.0787	27.3	11.72
St. 5.	*1932. 2.XI*		*57°02′ N.*				*20°10′ E.*	*(Gotland)*		
0	8.90	8.09	8.17	40	5	5	3.8401	6.9614	24.7	12.26
20	8.50	7.94	7.85	40	5	3	3.8849	7.0422		12.26
40	6.20	7.66	8.18	40	5	2	4.0051	7.2592	24.7	12.26
60	3.90	7.39	8.10	34	5	2	4.1052	7.4399		11.37
80	3.80	6.97	4.38	28	17	12	5.1010	9.2373	27.9	9.06
100	4.10	6.95	4.07	28	32	14	5.4801	9.9216		9.06
120	4.50	6.90	2.36	20	40	26	5.9203	10.7161	30.5	7.62
140	4.60	6.87	0.62	18	40	60	6.1319	11.0981		7.62
160	4.90	6.88	0.42	18	46	120	6.2752	11.3527	33.6	7.62

Die tiefste der von uns untersuchten Stellen befindet sich zwischen der lettländischen Küste und der Insel Gotland (St. 5 der Karte, Tiefe etwa 230 m.). Spalte 2 der Tabellen zeigt, dass die Wassertemperaturen mit der Tiefe abnehmen, doch nur bis etwa 60—80 m., darauf aber wieder ansteigen. In dieser Tiefe ändert sich auch, und zwar sprunghaft,

Tabelle 3.

m.	t°	pH	O_2 cm.³/l.	NH_4' mg.N/m.³	$NO_3'+NO_2'$ mg.N/m.³	PO_4''' mg.P/m.³	Organ. Stoffe $KMnO_4$ mg./l.
St. 1.	*1933. 23.X.*	*57°53′ N.*	*24°06′.4 E.*	*(Ainazi)*			
0	9.20	8.20	6.98	24	15	2	17.98
10	9.78	8.16	7.05	20	15	2	17.98
20	9.80	7.90	6.60	20	20	3	17.82
St. 2.	*1933. 7.X.*	*57°19′ N.*	*24°04′ E.*	*(Kurmrags)*			
0	11.55	8.18	8.75	24	20	4	19.60
10	11.55	7.98	7.84	24	35	5	19.60
20	11.60	7.80	8.69	28	35	6	18.94
30	8.85	7.81	8.84	28	35	6	18.94
40	6.95	7.60	7.81	28	45	10	17.58
St. 3.	*1933. 7.X.*	*57°28′.5 N.*	*23°20′ E.*	*(Mersrags)*			
0	11.40	8.13	7.50	20	0	2	17.34
10	11.38	8.14	7.59	28	0	3	17.00
20	11.38	8.00	7.07	30	0	3	17.00
30	5.05	7.85	7.67	30	0	3	17.00
40	4.12	7.45	5.42	30	45	8	15.65
St. 4.	*1933. 22.X.*	*57°43′.7 N.*	*22°06′.6 E.*	*(Irbesche Meerenge)*			
0	8.72	8.13	7.19	26	0	5	14.15
10	8.42	7.96	7.38	26	6	10	13.44
20	8.38	7.90	7.29	20	6	12	13.44
St. 6.	*1933. 17.X.*	*56°15′.6 N*	*20°37′.2 E.*	*(Pape)*			
0	10.50	8.15	8.50	28	0	2	11.70
10	10.45	8.12	8.24	28	0	2	11.70
20	9.70	8.08	8.05	28	2	2	11.60
30	9.70	7.80	8.14	20	2	3	11.27
St. 5.	*1933. 18.X.*	*57°20′.5 N.*	*19°56′.5 E.*	*(Gotland)*			
0	10.80	8.16	7.22	30	0	2	11.49
20	10.72	8.11	7.12	30	0	2	11.49
40	10.10	8.02	7.21	30	4	2	11.43
60	10.10	7.84	7.66	30	4	2	10.77
80	8.01	7.62	4.50	28	12	6	10.10
100	4.10	7.38	3.10	28	50	17	9.98
120	4.25	7.22	2.93	25	50	25	9.86
140	4.40	7.24	2.01	25	50	34	9.74
160	4.60	7.20	1.22	25	40	110	9.56
180	4.72	7.23	0.79	20	40	140	9.56
200	4.78	7.24	0.77	20	40	140	9.56
220	4.20	7.21	0.55	20	80	140	9.46

die Zusammensetzung des Wassers, sodass man hier von der Grenze zweier deutlich unterscheidbaren Schichten sprechen kann. Der Sauerstoffgehalt sinkt plötzlich um einige 50 %, die Phosphat- und Stickstoffmengen dagegen werden bedeutend grösser. Auch die Gesamtmenge an Salzen steigt. Diese tief greifenden Veränderungen lassen sich erklären, wenn man bedenkt, dass das Licht bis zu etwa 80 m. ins Meer eindringt, und dass daher bis zu dieser Tiefe ein Pflanzenleben möglich ist.

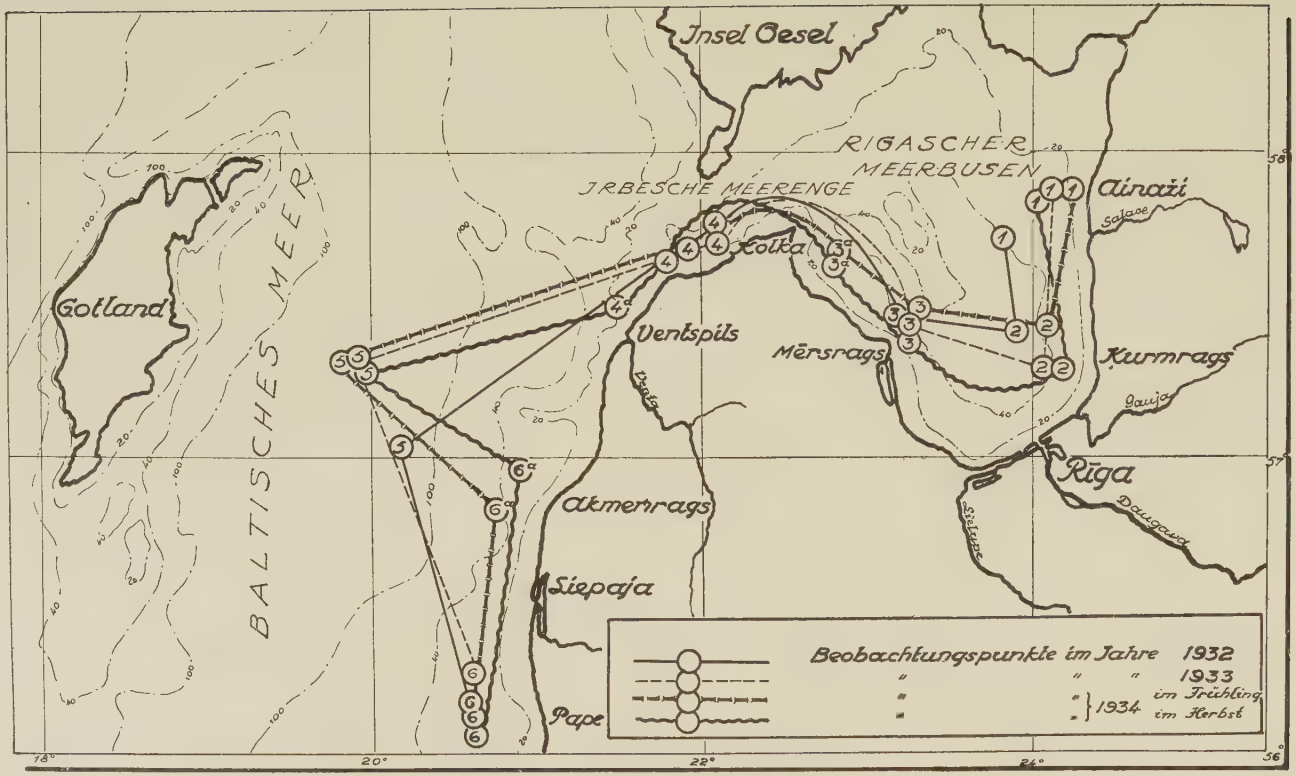
Insel Oesel
RIGASCHER MEERBUSEN
IRBESCHE MEERENGE
Ainaži
Salaca
Kolka
Gotland
BALTISCHES MEER
Ventspils
Mērsrags
Kurmrags
Gauja
Riga
Daugava
Akmenrags
Šiepaja
Pape
Beobachtungspunkte im Jahre 1932
" " " 1933
" " " } 1934 im Frühling
" " " } 1934 im Herbst
18°
20°
22°
24°
56°
57°
58°

Tabelle 4.

m.	t°	pH	O_2 cm.³/l.	$\frac{O_2}{O_2'} \cdot 100$	NH_4' mg.N/m.³	$NO_3' + NO_2'$ mg.N/m.³	PO_4''' mg.P/m.³
St. 1.	*1934. 28. VI.*		*57°54'.5 N.*	*24°14' E.*	*(Ainazi)*		
0	16.98	8.22	7.57	115.2	16	5	2
10	13.10	8.17	6.41	90.3			
20	3.70	7.80	6.17	69.9	16	8	8
St. 2.	*1934. 10. VI.*		*57°24'.3 N.*	*24°08'.8 E.*	*(Kurmrags)*		
0	12.20	7.98	7.76	107.2	26	0	2
10	9.80	8.15	8.01	104.8			
20	7.62	8.17	7.01	87.4	25	0	4
30	1.55	7.82	8.74	93.5			
40	1.42	7.78	7.84	84.0	25	45	6
St. 3.	*1934. 9.VI.*		*57°30' N.*	*23°22'.5 E.*	*(Mersrags)*		
0	11.95	8.16	8.19	112.8	30	2	2
10	11.40	8.14	8.26	112.2			
20	7.02	7.88	8.93	109.8	30	2	4
30	1.70	7.82	8.73	93.9			
40	2.50	7.49	6.07	67.0	22	5	7
St. 3a.	*1934. 9.VI.*		*57°42'.4 N.*	*22°52' E.*	*(Roja)*		
0	11.05	8.18	8.18	110.4	20	3	8
10	9.85	8.16	8.39	110.4			
20	8.60	8.12	8.18	103.9	20	3	6
30	6.48	7.71	7.91	96.6			
40	6.20	7.79	6.41	77.8	20	3	6
St. 4.	*1934. 9.VI.*		*57°41'.6 N.*	*21°56'.8 E.*	*(Irbesche Meerenge)*		
0	12.55	8.15	8.05	112.4	24	2	2
10	9.80	8.10	7.56	99.9			
20	6.25	8.06	7.88	96.0	18	5	0

Das Phytoplankton verbraucht Nitrate und Phosphate und entzieht der Kohlensäure den Kohlenstoff, wobei der Sauerstoff frei wird, im Wasser gelöst bleibt und den hohen Sauerstoffgehalt der oberen Meeresschichten verursacht. Unterhalb 80 m. kann eine bedeutende Photosynthese nicht mehr vor sich gehen; die im Wasser vorhandenen Phosphate und Nitrate werden nicht verbraucht, und Sauerstoff wird nicht entwickelt: daher das plötzliche Ansteigen der Phosphate und Nitrate und die Verminderung des Sauerstoffs. Diese euphotische Schicht erstreckt sich je nach den geographischen, physikalischen und anderen Umständen bis zu einer Tiefe von 30—80 m. Der Rigasche Meerbusen ist seicht, und daher ist ein Pflanzenleben bis zum Meeresgrunde anzutreffen.

Doch lässt sich aus unseren Untersuchungen folgern, dass an manchen Stellen, die etwa 40 m. tief sind, eine bedeutendere Photosynthese nur bis zu 30 m. vor sich geht.

Tabelle 4. (fortgesetzt)

m.	t°	pH	O_2 cm.³/l.	$\frac{O_2}{O_2'} \cdot 100$	NH_4^+ mg.N/m.³	$NO_3' + NO_2'$ mg.N/m.³	PO_4''' mg.P/m.³
St. 6a.	*1934. 8.VI.*		*56°50′ N*	*20°48′ E.*	*(Akmenrags)*		
0	11.45	8.16	7.89	108.4	20	8	8
10	11.45	8.14	7.79	107.0			
20	9.70	8.14	8.03	106.2	20	5	0
30	9.20	8.08	8.13	106.3			
40	4.20	7.78	8.19	94.9	28	5	2
St. 6.	*1934. 7.VI.*		*56°11′.2 N.*	*20°36′ E.*	*(Pape)*		
0	11.40	8.14	7.87	107.9	20	5	0
10	10.72	8.14	8.03	108.4			
20	4.80	8.08	7.96	93.5			
30	4.00	7.76	7.40	85.4	22	5	0
St. 5.	*1934. 8.VI.*		*57°20′ N.*	*19°57′ E.*	*(Gotland)*		
0	9.60	8.12	8.49	112.0	18	2	4
20	6.02	8.10	8.21	99.5	24	—	4
40	5.50	8.08	8.19	98.1	24	10	2
60	3.50	7.78	10.78	122.9	35	—	2
80	4.32	7.54	4.02	47.2	35	45	6
100	4.87	7.52	3.47	41.8	35	—	20
120	4.90	7.48	3.06	37.0	35	60	45
140	4.90	7.48	4.56	55.3	37	—	70
160	4.90	7.35	2.01	24.4	37	60	85
180	4.90	7.35	2.03	24.6	37	50	40
200	4.89	7.60	4.16	50.5	25	—	28
220	4.89	7.60	4.96	60.3	12	50	20

Im einzelnen wäre zu den Zahlen noch folgendes zu bemerken.

Die Konzentration der Wasserstoffionen (pH) schwankt an der Oberfläche zwischen 8.09 und 8.20, am Meeresgrunde zwischen 6.88 und 8.06. Es erweist sich also, dass die Reaktion des Meerwassers basisch ist, mit zunehmender Tiefe jedoch immer schwächer basisch wird. Im Jahre 1932 war das Wasser bei Gotland bis zu einer Tiefe von 60 m. noch basisch, bei 80 m. jedoch schon sauer (pH = 6.97).

Sauerstoff. In den oberen Schichten ist das Wasser an Sauerstoff gewöhnlich übersättigt, da hier eine rege Photosynthese vor sich geht und Sauerstoff bei der Assimilation der Kohlensäure frei wird.

Die Menge des *Ammoniak-Stickstoffs* beträgt an der Oberfläche 12—40 mg., am Meeresgrunde 10 bis 33 mg. in 1 Kubikmeter.

In den oberen Schichten, wo Assimilation stattfindet, ist gewöhnlich mehr Ammoniak anzutreffen als in grösserer Tiefe.

Ziemlich bedeutende Mengen Ammoniak werden dem Meere durch das Süsswasser der Flüsse zugeführt. Ausserdem bildet es sich auch im Meerwasser selbst, und zwar durch Zerfall von stickstoffhaltigen organischen Stoffen. Da nun die Assimilationsschicht verhältnismässig mehr Sauerstoff enthält, so kann die chemische Spaltung hier in grösserem Ausmass stattfinden als in den unteren Schichten, wo der

Tabelle 5.

m.	t°	pH	O_2 cm.³/l.	$\frac{O_2}{O_2'} \cdot 100$	NH_4' mg.N/m.³	$NO_3' + NO_2'$ mg.N/m.³	PO_4''' mg.P/m.³
St. 1.	*1934. 14.XI.*		*57°50'.5 N.*	*24°04' E.*	*(Ainazi)*		
0	8.82	8.14	7.91	101.4	32	0	0
10	8.80	8.14	7.82	100.3	—	—	—
20	8.62	8.14	7.74	99.0	30	2	0
St. 2.	*1934. 11.X.*		*57°19'.2 N.*	*24°05'.5 E.*	*(Kurmrags)*		
0	13.90	8.14	6.74	96.7	35	0	3
10	13.90	8.14	6.72	96.4	—	—	—
20	13.90	8.14	6.58	94.4	35	0	3
30	13.15	8.14	6.06	86.3	—	—	—
40	8.02	7.42	4.73	59.8	26	25	8
St. 3.	*1934. 11.X.*		*57°28'.6 N.*	*23°20' E.*	*(Mersrags)*		
0	13.20	8.14	6.09	86.1	20	0	0
10	13.20	8.12	8.00	113.2	—	—	—
20	8.98	8.06	6.76	87.2	20	0	3
30	5.62	7.72	6.82	81.3	—	—	—
40	5.58	7.64	5.13	61.0	32	30	5
St. 3a.	*1934. 17.X.*		*57°42'.3 N*	*22°52'.2 E.*	*(Roja)*		
0	11.58	8.16	6.94	94.9	18	0	5
10	11.68	8.19	6.71	92.0	—	—	—
20	11.98	8.19	6.48	89.6	12	2	5
30	11.90	8.19	6.57	90.6	—	—	—
40	11.80	8.10	6.53	89.9	10	5	7
St. 4.	*1934. 17.X.*		*57°41'.2 N.*	*21°49'.7 E.*	*(Irbesche Meerenge)*		
0	13.50	8.18	6.42	92.1	15	0	3
10	13.50	8.20	6.87	98.6	—	—	—
20	13.50	8.02	7.70	110.5	38	3	3

Sauerstoffgehalt geringer ist. Durch diese Überlegung lässt sich die Beobachtung erklären, dass dort, wo Pflanzenleben anzutreffen ist, sich auch am meisten Ammoniak bildet.

Nach den herrschenden Ansichten können die Pflanzen sowohl den Nitrat- als auch den Ammoniak-Stickstoff gleich gut assimilieren. Unsere Untersuchungen zeigen jedoch, dass an manchen Stellen, besonders in den oberen Teilen der Assimilationsschicht, Nitrate so gut wie völlig verbraucht werden, Ammoniak dagegen fast garnicht angegriffen wird. Es scheint also, dass das Phytoplankton des Meeres den Ammoniak-Stickstoff nicht ausnutzt.

Nitrate und *Nitrite*. Da nur äusserst geringe Mengen Nitrit im Meerwasser vorkommen, so haben wir sie zusammen mit den Nitraten bestimmt. Der Nitratgehalt ist im ganzen recht gering: an der Oberfläche beträgt er 0 bis 20 mg., am Meeresgrunde 3 bis 80 mg. in 1 Kubikmeter. An manchen Stellen sind sogar garkeine Nitrate gefunden worden. Der Nitratgehalt nimmt von oben nach unten allmählich zu; in einer gewissen Tiefe — im Rigaschen Meerbusen unterhalb 30 m., bei Gotland unterhalb 80 m. — zeigt sich ein plötzliches sehr

Tabelle 5. (fortgesetzt).

m.	t°	pH	O_2 cm.³/l.	$\frac{O_2}{O_2'} \cdot 100$	NH_4' mg.N/m.³	$NO_3' + NO_2'$ mg.N/m.³	PO_4''' mg.P/m.³
St. 4a.	*1934. 17.X.*		*57°33′ N.*	*21°02′ E.*	*(Ventspils)*		
0	13.20	8.10	6.82	97.3	12	2	3
10	13.20	8.14	6.82	97.3	—	—	—
20	13.20	8.12	6.66	95.0	30	5	3
St. 5.	*1934. 18.X.*		*57°20′ N.*	*19°57′ E.*	*(Gotland)*		
0	12.68	8.14	7.54	106.2	25	0	2
20	12.68	8.14	7.10	100.0	—	—	—
40	8.50	7.76	7.50	96.4	25	2	2
60	3.70	7.69	7.50	85.7	—	—	—
80	4.20	7.48	7.35	86.2	18	15	5
100	4.80	7.48	4.00	47.9	—	—	—
120	4.80	7.48	3.81	45.8	15	20	24
140	4.90	7.42	3.01	36.4	—	—	—
160	4.90	7.46	3.42	41.4	10	25	32
180	4.90	7.48	3.80	45.9	—	—	—
200	4.90	7.52	4.02	48.7	10	65	36
St. 6.	*1934. 2.XI.*		*56°06′.8 N.*	*20°32′ E.*	*(Pape)*		
0	12.35	8.10	7.20	100.8	16	0	3
10	12.35	7.82	7.28	102.0	—	—	—
20	12.35	7.76	8.00	112.0	—	—	—
30	12.35	7.72	7.85	109.9	16	2	3
St. 6a.	*1934. 2.XI.*		*56°58′ N.*	*20°45′.5 E.*	*(Akmenrags)*		
0	11.02	8.18	7.58	103.1	22	0	0
10	11.02	8.18	7.40	100.7	—	—	—
20	11.02	8.18	8.06	109.7	22	0	0
30	11.02	8.18	7.51	102.2	—	—	—
40	11.02	8.18	8.19	111.4	18	0	0
50	11.02	8.14	7.67	104.4	—	—	—
60	11.02	8.10	7.20	97.9	14	2	0

bedeutendes Ansteigen. Die Erklärung liegt, wie schon gesagt, darin, dass bis zu den genannten Tiefen noch Pflanzenleben möglich ist, und daher die Nitrate der oberen Schichten verbraucht werden, unterhalb dieser Grenzen jedoch die Nitratmengen des Meerwassers unverbraucht bleiben.

Von den *Phosphaten* lässt sich dasselbe sagen, wie von den Nitraten. Auch ihre Menge ist sehr gering: an der Oberfläche 0 bis 8 mg., am Meeresgrunde 0 bis 140 mg. in 1 Kubikmeter. Da die Phosphate für die Pflanzenwelt zu den lebenswichtigsten Stoffen gehören, so finden wir bei ihnen dieselbe Gesetzmässigkeit in der Verteilung wie bei den Nitraten: ein allmähliches Ansteigen von oben nach unten und ein plötzliches Anschwellen unterhalb der Grenze des Pflanzenlebens.

Organische Stoffe. Das Wasser des Rigaschen Meerbusens enthält mehr organische Stoffe als das des Baltischen Meeres, was sich durch den Einfluss der Flüsse erklärt. Grössere Mengen finden sich in der Gegend von Ainazi, Kurmrags und Mersrags (St. 1, 2, 3). Je weiter

man sich von den Küsten entfernt, desto mehr sinkt der Gehalt an organischen Stoffen. Auch in grösseren Tiefen ist er geringer als in den oberen Schichten.

Der *Jodgehalt* schwankt von 8.2 bis 24.7 mg. und von 8.9 bis 33.6 mg. in 1 Kubikmeter. Die ersten beiden Zahlen beziehen sich auf die Oberfläche, die letzten auf den Meeresgrund. Im allgemeinen kann man sagen, dass der Jodgehalt mit steigender Tiefe zunimmt und dass eine solche Zunahme auch beobachtet wird, wenn man sich von der Küste entfernt. So enthält zum Beispiel bei Kurmrags das Oberflächenwasser 8.2 mg. Jod, am Meeresgrunde dagegen (in 40 m. Tiefe) 14.4 mg. in 1 Kubikmeter. In der Irbeschen Meerenge sind die entsprechenden Zahlen 14.8 mg. und 22.4 mg. (in 30 m. Tiefe) und bei Gotland 24.7 mg. und 33.6 mg. (in 160 m. Tiefe).

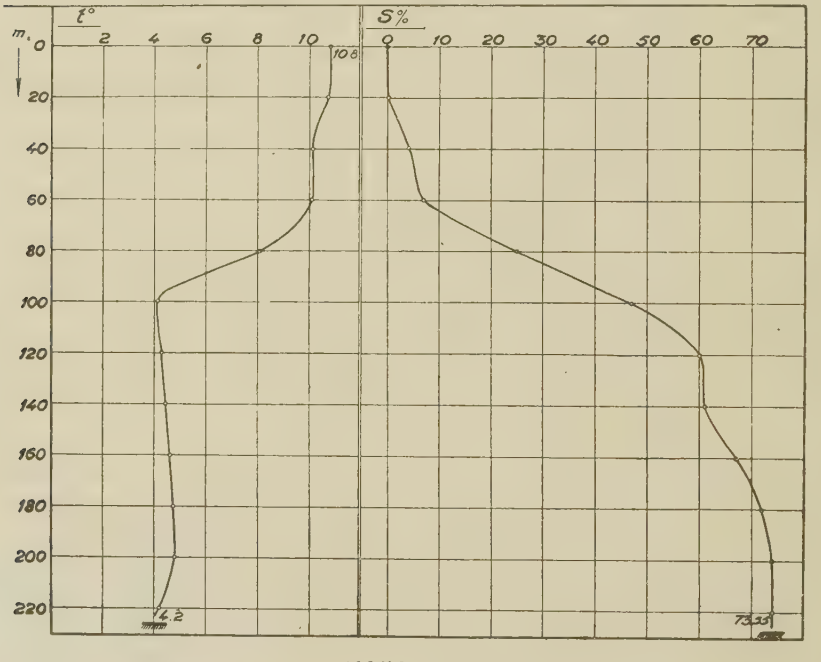

Abbildung 1.

Aus den Tabellen 6, 7 und 8 (auch aus 2) ist zu ersehen, dass die Zusammensetzung des Wassers im Rigaschen Meerbusen und im Baltischen Meere nicht einheitlich ist, sondern dass der Gehalt an Salzen von oben nach unten zunimmt. Das bezieht sich sowohl auf den Gesamtgehalt, als auch auf den Gehalt an den einzelnen Bestandteilen, und zwar ist die prozentische Zunahme bei allen Salzen die gleiche. Die folgende Zusammenstellung zeigt das deutlich. Die Wasserproben stammen aus der Gegend von Gotland, und sind in den Jahren 1933 und 1934 untersucht worden (St. 5, Tab. 6 und 7).

					1933		1934
Cl'	Gehalt	von 0	bis 220	m. angewachsen um	74.57 %	und	74.64 %
SO_4''	„	„	„	„	74.49 %	„	74.66 %
Na'	„	„	„	„	74.47 %	„	74.61 %
K'	„	„	„	„	75.43 %	„	75.61 %
Mg''	„	„	„	„	74.50 %	„	74.08 %
Ca''	„	„	„	„	60.03 %	„	60.74 %
S ‰	„	„	„	„	73.55 %	„	73.62 %

Man ersieht daraus, dass die prozentische Zunahme der Bestandteile des Wassers ausser bei Kalzium und S ‰ vollkommen gleichmässig ist. Die kleinen Unterschiede beruhen wohl auf den unvermeidlichen Analysenfehlern. Bemerkenswert ist auch die Tatsache, dass diese Zunahme in diesen beiden Jahren völlig gleich war, obwohl der Gehalt an den einzelnen Salzen (aus derselben Tiefe) von Jahr zu Jahr schwankte, wie aus den betreffenden Tabellen hervorgeht.

Abbildung 1 gibt an, wie der Salzgehalt in den einzelnen Tiefenstufen zunimmt: bis 60 m. Tiefe beobachtet man ein allmähliches Anwachsen um 7 %; bei etwa 80 m. steigt der Salzgehalt plötzlich und erreicht einen Zuwachs von 25 %.

Das Oberflächenwasser enthielt durchschnittlich folgende Salzmengen:

Bei Kurmrags (St. 2)	4.86 ‰
Bei Ainazi (St. 1)	5.03 „
Bei Mersrags (St. 3)	5.23 „
In der Irbeschen Meerenge (St. 4)	5.71 „
Bei Akmenrags (St. 6a)	6.66 „
Bei Pape (St. 6)	6.74 „
Bei Gotland (St. 5)	6.73 „

Der Salzgehalt nimmt also mit der Entfernung von der Küste, wo er am niedrigsten ist, zu, was man natürlich dem Einfluss des durch die Flüsse einströmenden Süsswassers zuschreiben kann.

Wie bekannt, steigt die Menge aller Bestandteile des Meerwassers mit zunehmender Tiefe.

Bei der Titrationsalkalinität ist es im Rigaschen Meerbusen und an den der Küste näher liegenden Stellen des Baltischen Meeres gerade umgekehrt: an der Oberfläche ist sie grösser und nimmt mit der Tiefe ab. Hier scheint also eine Ausnahme vorzuliegen, denn die Alkalinität des Wassers bei Gotland, sowie auch im Bottnischen und Finnischen Meerbusen und im Ozean schliesst sich der allgemeinen Regel an und nimmt mit steigender Tiefe zu.

Auch in anderer Beziehung ist ein Unterschied vorhanden. Während z. B. im Bottnischen und Finnischen[12]) Meerbusen die Alkalinität in der Nähe der Küste nur etwa 0.75 mg. äqu. in 1 l. beträgt und mit

Tabelle 6.

m.	Cl' g./kg.	SO_4'' g./kg.	HCO_3' g./kg.	$Na^{\cdot}$ g./kg.	$K^{\cdot\cdot}$ g./kg.	$Ca^{\cdot\cdot}$ g./kg.	$Mg^{\cdot\cdot}$ g./kg.	S ‰ Kationen + Anionen	S ‰ nach Knudsen	S‰ Differenz	Titrations Alkalinität "A" in Milliäqu/l.
St. 1.	*1933. 23.X.*		*57°53′ N.*	*24°04′.6 E.*	*(Ainazi)*						
0	2.7778	0.3953	0.1040	1.5445	0.0555	0.0775	0.1947	5.1493	5.0439	0.11	1.7041
10	2.7864	0.3957	0.1040	1.5515	0.0560	0.0780	0.1956	5.1672	5.0595	0.11	1.7041
20	2.8552	0.4058	0.1031	1.5869	0.0574	0.0814	0.2004	5.2902	5.1836	0.11	1.6902
St. 2.	*1933. 7.X.*		*57°19′ N.*	*24°04′ E.*	*(Kurmrags)*						
0	2.6316	0.3723	0.1057	1.4600	0.0529	0.0768	0.1845	4.8838	4.7800	0.10	1.7321
10	2.6316	0.3734	0.1048	1.4600	0.0529	0.0771	0.1847	4.8845	4.7800	0.10	1.7181
20	2.6522	0.3768	0.1040	1.4709	0.0533	0.0781	0.1862	4.9215	4.8172	0.10	1.7041
30	2.7090	0.3861	0.1040	1.5008	0.0542	0.0810	0.1904	5.0255	4.9197	0.11	1.7041
40	3.0130	0.4270	0.1040	1.6674	0.0608	0.0872	0.2115	5.5709	5.4685	0.10	1.7041
St. 3.	*1933. 7.X.*		*57°28′.5 N.*	*23°20′ E.*	*(Mersrags)*						
0	2.8122	0.3988	0.1023	1.5574	0.0563	0.0832	0.1974	5.2076	5.1060	0.10	1.6762
10	2.8122	0.3988	0.1023	1.5574	0.0563	0.0832	0.1974	5.2076	5.1060	0.10	1.6762
20	2.8122	0.3988	0.1023	1.5574	0.0563	0.0832	0.1974	5.2076	5.1060	0.10	1.6762
30	2.8122	0.4007	0.1023	1.5574	0.0563	0.0840	0.1974	5.2103	5.1060	0.10	1.6762
40	3.1562	0.4488	0.1014	1.7460	0.0630	0.0910	0.2212	5.8276	5.7269	0.10	1.6622
St. 4.	*1933. 22.X.*		*57°43′.7 N.*	*22°06′.6 E.*	*(Irbesche Meerenge)*						
0	3.3178	0.4696	0.1001	1.8351	0.0664	0.0916	0.2319	6.1125	6.0186	0.09	1.6400
10	3.5831	0.5064	0.0968	1.9807	0.0721	0.0969	0.2505	6.5865	6.4975	0.09	1.5862
20	3.6016	0.5083	0.0968	1.9915	0.0724	0.0972	0.2514	6.6192	6.5309	0.09	1.5862

St. 6.	*1933. 17.X.*		*56°15′.6 N.*		*20°37′.2 E.*	*(Pape)*					
0	3.6551	0.5150	0.0958	2.0213	0.0735	0.0971	0.2545	6.7123	6.6275	0.08	1.5703
10	3.6704	0.5193	0.0958	2.0291	0.0738	0.0976	0.2556	6.7416	6.6551	0.09	1.5703
20	3.7158	0.5232	0.0951	2.0545	0.0744	0.0982	0.2584	6.8196	6.7370	0.08	1.5594
30	3.7158	0.5247	0.0943	2.0545	0.0744	0.0982	0.2588	6.8207	6.7370	0.08	1.5459
St. 5.	*1933. 18.X.*		*57°20′.5 N.*		*19°56′.5 E.*	*(Gotland)*					
0	3.5621	0.5018	0.0878	1.9700	0.0712	0.0941	0.2476	6.5346	6.4596	0.08	1.4389
20	3.5638	0.5027	0.0878	1.9704	0.0716	0.0943	0.2480	6.5386	6.4627	0.08	1.4389
40	3.7014	0.5216	0.0886	2.0469	0.0744	0.0979	0.2573	6.7881	6.7110	0.08	1.4528
60	3.8218	0.5385	0.0886	2.1131	0.0765	0.1016	0.2656	7.0057	6.9283	0.08	1.4528
80	4.4685	0.6314	0.0920	2.4711	0.0898	0.1154	0.3102	8.1784	8.0956	0.08	1.5086
100	5.2718	0.7433	0.0950	2.9148	0.1060	0.1315	0.3665	9.6289	9.5456	0.08	1.5573
120	5.7276	0.8087	0.0980	3.1663	0.1146	0.1380	0.3981	10.4513	10.3683	0.08	1.6064
140	5.7620	0.8129	0.0989	3.1853	0.1156	0.1396	0.4005	10.5148	10.4304	0.08	1.6204
160	5.9856	0.8474	0.1031	3.3095	0.1209	0.1460	0.4166	10.9291	10.8340	0.10	1.6902
180	6.1627	0.8683	0.1031	3.4068	0.1239	0.1493	0.4283	11.2424	11.1537	0.09	1.6902
200	6.2178	0.8756	0.1031	3.4373	0.1249	0.1506	0.4321	11.3414	11.2531	0.09	1.6902
220	6.2178	0.8756	0.1031	3.4373	0.1249	0.1506	0.4321	11.3414	11.2531	0.09	1.6902

Tabelle 7.

m.	Cl' g./kg.	SO_4'' g./kg.	HCO_3' g./kg.	$Na^{\cdot}$ g./kg.	$K^{\cdot}$ g./kg.	$Ca^{\cdot\cdot}$ g./kg.	$Mg^{\cdot\cdot}$ g./kg.	S ‰ Anionen + Kationen	S ‰ nach Knudsen	S ‰ Differenz	Titrations-Alkalinität "A" in Milliäqu/l.
St. 1.	*1934. 28.VI.*		*57°54'5 N.*		*24°14' E.*		*(Ainazi)*				
0	2.6864	0.3807	0.1055	1.4882	0.0535	0.0810	0.1884	4.9837	4.8790	0.10	1.7285
10	2.6864										
20	2.8781	0.4068	0.1055	1.5905	0.0580	0.0858	0.2011	5.3198	5.2141	0.11	1.7285
St. 2.	*1934. 10.VI.*		*57°24'.3 N*		*24°08'.8 E.*		*(Kurmrags)*				
0	2.5625	0.3643	0.1040	1.4194	0.0515	0.0766	0.1799	4.7582	4.6553	0.10	1.7050
10	2.5625										
20	2.6761										
30	2.9719										1.6841
40	2.9839	0.4235	0.1050	1.6526	0.0599	0.0861	0.2088	5.5198	5.4159	0.10	1.7207
St. 3.	*1934. 9.VI.*		*57°30' N.*		*23°22'.5 E.*		*(Mersrags)*				
0	2.7122	0.3848	0.1031	1.5079	0.0542	0.0814	0.1904	5.0340	4.9255	0.11	1.6893
10	2.7122										
20	2.8584										
30	2.9667										1.6893
40	3.3967	0.4830	0.0999	1.8784	0.0686	0.0943	0.2376	6.2585	6.1610	0.10	1.6370
St. 3a.	*1934. 9.VI.*		*57°42'.4 N.*		*22°52' E.*		*(Roja)*				
0	2.8756	0.4083	0.1039	1.5919	0.0578	0.0866	0.2016	5.3257	5.2205	0.11	1.7024
10	2.8807										
20	2.9495	0.4191									
30	3.3296										1.7024
40	3.3795	0.4806	0.0999	1.8702	0.0676	0.0953	0.2362	6.2293	6.1300	0.10	1.6370
St. 4.	*1934. 9.VI.*		*57°41'.6 N.*		*21°56'.8 E.*		*(Irbesche Meerenge)*				
0	3.0097	0.4268	0.1024	1.6647	0.0605	0.0903	0.2104	5.5648	5.4625	0.10	1.6789
10	3.3365										
20	3.6512	0.5174	0.0951	2.0187	0.0730	0.0986	0.2557	6.7097	6.6204	0.09	1.5586

St. 6a.	*1934. 8.VI.*		*56°50′ N.*	*20°48′ E.*	*(Akmenrags)*						
0	3.6461	0.5145	0.0941	2.0163	0.0730	0.0966	0.2543	6.6949	6.6112	0.08	1.5429
10	3.6547										
20	3.7527										1.5220
30	3.7871										
40	3.8352	0.5408	0.0929	2.1209	0.0771	0.1012	0.2667	7.0348	6.9525	0.08	1.5220
St. 6.	*1934. 7.VI.*		*56°11′.2 N.*	*20°36′ E.*	*(Pape)*						
0	3.6117	0.5099	0.0967	1.9973	0.0726	0.0957	0.2515	6.6354	6.5491	0.09	1.5847
10	3.6117										
20	3.7080										
30	3.7974	0.5354	0.0935	2.1003	0.0764	0.1003	0.2645	6.9691	6.8843	0.08	1.5324
St. 5.	*1934. 8.VI.*		*57°20′ N.*	*19°57′ E.*	*(Gotland)*						
0	3.7321	0.5262	0.0903	2.0639	0.0746	0.0988	0.2592	6.8451	6.7664	0.08	1.4801
20	3.7337										
40	3.7881										1.5063
60	3.9642	0.5577	0.0920	2.1914	0.0800	0.1047	0.2756	7.2656	7.1854	0.08	1.5072
80	5.0047	0.7051	0.0927	2.7666	0.1001	0.1264	0.3485	9.1441	9.0633	0.08	1.5193
100	5.6414	0.7960	0.0988	3.1192	0.1135	0.1393	0.3922	10.3004	10.2127	0.09	1.6189
120	5.9820	0.8464	0.1015	3.3080	0.1202	0.1446	0.4157	10.9184	10.8275	0.09	1.6632
140	6.1685										
160	6.2232										1.6846
180	6.3201										
200	6.4092										
220	6.5182	0.9191	0.1034	3.6039	0.1310	0.1578	0.4521	11.8855	11.7954	0.09	1.6893

Tabelle 8.

m.	Cl' g./kg.	SO_4'' g./kg.	HCO_3' g./kg.	Na^* g./kg.	K^* g./kg.	Ca^{**} g./kg.	Mg^{**} g./kg.	S ‰ Anionen + Kationen	S ‰ nach Knudsen	S ‰ Differenz	Titrationsalkalinität "A" in Milliäqu l.	B_2O_3 mg./kg.
St. 1.	*1934. 14.XI.*		*57°50′.5 N.*		*24°04′ E.*	*(Ainazi)*						
0	2.8285	0.4019	0.1062	1.5672	0.0561	0.0820	0.1985	5.2404	5.1354	0.10	1.7407	2.5111
10	2.8398											
20	2.8447	0.4040	0.1062	1.5757	0.0569	0.0830	0.1988	5.2693	5.1647	0.10	1.7407	2.5435
St. 2.	*1934. 11.X.*		*57°19′.2 N.*		*24°05′.5 E.*	*(Kurmrags)*						
0	2.7847	0.3952	0.1062	1.5427	0.0554	0.0831	0.1952	5.1625	5.0564	0.10	1.7410	2.4987
10	2.7847											
20	2.7847											
30	2.7944										1.7276	
40	3.1527	0.4481	0.1049	1.7460	0.0627	0.0917	0.2213	5.8274	5.7206	0.10	1.7200	2.7888
St. 3.	*1934. 11.X.*		*57°28′.6 N.*		*23°20′ E.*	*(Mersrags)*						
0	2.7918	0.3958	0.1054	1.5458	0.0558	0.0809	0.1954	5.1704	5.0692	0.10	1.7276	2.4694
10	2.7918											
20	2.8901											
30	3.0214										1.7145	
40	3.1802	0.4513	0.1022	1.7593	0.0636	0.0913	0.2229	5.7704	5.7703	0.10	1.6753	2.8331
St. 3a.	*1934. 17.X.*		*57°42′.3 N.*		*22°52′.2 E.*	*(Roja)*						
0	3.0181	0.4286	0.1038	1.6705	0.0600	0.0875	0.2109	5.5794	5.4777	0.10	1.7013	2.6695
10	3.0343											
20	3.1089											
30	3.1510										1.6727	
40	3.1575	0.4480	0.1020	1.7483	0.0631	0.0913	0.2217	5.8319	5.7293	0.10	1.6727	2.7930
St. 4.	*1934. 17.X.*		*57°41′.2 N.*		*21°49′.7 E.*	*(Irbesche Meerenge)*						
0	3.6875	0.5214	0.0942	2.0392	0.0734	0.0995	0.2578	6.7730	6.6859	0.09	1.5445	2.9568
10	3.6875											
20	3.6875	0.5217	0.0947	2.0392	0.0734	0.0999	0.2581	6.7743	6.6859	0.09	1.5522	2.9571

St. 4a.	*1934. 17.X. 57°33′ N. 21°02′ E. (Ventspils)*											
0	3.7025	0.5231	0.0958	2.0471	0.0736	0.0981	0.2577	6.7979	6.7130	0.08	1.5705	2.9686
10	3.7025											
20	3.7025	0.5235	0.0958	2.0474	0.0736	0.0984	0.2577	6.7989	6.7130	0.08	1.5705	2.9686
St. 5.	*1934. 18.X. 57°20′ N. 19°57′ E. (Gotland)*											
0	3.6308	0.5123	0.0910	2.0074	0.0722	0.0962	0.2527	6.6626	6.5836	0.08	1.4920	2.8709
20	3.6535											
40	3.7054										1.5418	
60	3.7183											
80	4.8708	0.6863	0.0960	2.6926	0.0974	0.1251	0.3385	8.9067	8.8218	0.08	1.5732	3.8745
100	5.5046											
120	5.8077	0.8189	0.1004	3.2116	0.1156	0.1405	0.4031	10.5983	10.5129	0.08	1.6464	4.6197
140	5.9455											
160	6.0681										1.6755	
180	6.0881											
200	6.1805	0.8721	0.1022	3.4160	0.1230	0.1501	0.4301	11.2740	11.1858	0.09	1.6755	4.8771
St. 6.	*1934. 2.XI. 56°06′.8 N. 20°32′ E. (Pape)*											
0	3.7329	0.5271	0.0928	2.0639	0.0742	0.0989	0.2598	6.8496	6.7679	0.08	1.5208	2.9693
10	3.7329											
20	3.7329											
30	3.7329	0.5268	0.0928	2.0642	0.0746	0.0992	0.2595	6.8500	6.7679	0.08	1.5208	2.9575
St. 6a.	*1934. 2.XI. 56°58′ N. 20°45′.5 E. (Akmenrags)*											
0	3.7086	0.5233	0.0912	2.0509	0.0738	0.0983	0.2581	6.8042	6.7240	0.08	1.4946	2.9502
10	3.7086											
20	3.7086										1.4946	
30	3.7086											
40	3.7086										1.4946	
50	3.7086											
60	3.7086	0.5233	0.0912	2.0512	0.0741	0.0987	0.2578	6.8049	6.7240	0.08	1.4946	2.9737

zunehmender Entfernung von der Küste ansteigt, ist es in unseren Gewässern umgekehrt: je näher man der Küste kommt, desto grösser wird die Alkalinität, was wohl dem Süsswasser der Flüsse zu verdanken ist. So fanden wir 1933 an der Oberfläche:

Bei Kurmrags (St. 2)	1.732	mg.	äqu. l.
Bei Ainazi (St. 1)	1.704	„	„
Bei Mersrags (St. 3)	1.676	„	„
In der Irbeschen Meerenge (St. 4)	1.640	„	„
Bei Pape (St. 6)	1.570	„	„
Bei Gotland (St. 5)	1.439	„	„

Hier wäre noch anzuführen, dass die Alkalinität im Rigaschen Meerbusen um 0.6—0.7 mg. äqu. l. niedriger ist als im Ozean[13]). Das ist insofern bemerkenswert, weil unsere Flüsse durch Dolomite fliessen und daher bedeutende Mengen Karbonate dem Meere zuführen.

Aus den Tabellen 6, 7 und 8 ist ersichtlich, dass die nach der Formel von K n u d s e n berechnete Salzmenge (S $^0/_{00}$) niedriger ausfällt als die, welche man aus den direkt bestimmten Kationen und Anionen erhält, und zwar für den Rigaschen Meerbusen um 0.10 $^0/_{00}$, für das Baltische Meer um 0.085 S $^0/_{00}$.

Die ursprüngliche Knudsensche Formel S $^0/_{00} = 0.030 + 1.8050$ Cl *wäre also zu ändern und nähme dann folgende Gestalt an:*

für den Rigaschen Meerbusen S $^0/_{00} = 0.130 + 1.8050$ Cl

für das Baltische Meer S $^0/_{00} = 0.115 + 1.8050$ Cl.

Schon am Anfang dieser Arbeit wurde angedeutet, dass der seichte Rigasche Meerbusen (grösste Tiefe etwa 40 m.) vom offenen Meere verhältnismässig abgeschlossen ist, und dass daher der Einfluss des Süsswassers der in ihn mündenden Flüsse auf die Zusammensetzung seines Wassers recht bedeutend sein müsste. Das ist tatsächlich der Fall, doch werden dadurch die allgemeinen Gesetzmässigkeiten nicht aufgehoben, sondern nur verändert.

Die Tabellen 9, 10 und 11 geben an, wieviel mal der Gehalt an einem Bestandteil des Wassers grösser ist als der Chlorgehalt.

Diese Verhältniszahlen ermöglichen es, einen Überblick über den Einfluss des Süsswassers zu gewinnen: an der Küste, wo die Flüsse münden, sind diese Zahlen am grössten, und nehmen desto mehr ab, je mehr man sich dem Baltischen Meere nähert, da ja die Süsswasserzufuhr immer geringer wird. In der Irbeschen Meerenge, wo sich das Wasser des Rigaschen Meerbusens mit dem des Baltischen Meeres mischt, finden wir einen Zwischenwert.

Nicht alle Verhältniszahlen werden gleichmässig beeinflusst: am meisten ändert sich das Verhältnis von Kalzium, sowie der Alkalinität zu Chlor, am wenigsten das des Kaliums zu Chlor.

Betrachtet man nun die Änderung der Verhältniszahlen mit der Tiefe, so findet man, dass sie mit Ausnahme der spezifischen Alkalinität, die nach unten hin abnimmt, bis zu einer Tiefe von etwa 30 m. gleich ist. Bei 40 m. haben sich die Zahlen schon geändert. Das spricht dafür, dass eine vollständigere Vermischung des Meerwassers mit Süsswasser

Tabelle 9.

m.	$\frac{SO_4''}{Cl'}$	$\frac{Ca''}{Cl'}$	$\frac{Mg''}{Cl'}$	$\frac{Na'}{Cl'}$	$\frac{K''}{Cl'}$	$\frac{A}{Cl'}$
St. 1.	*1933. 23.X.*	*57°53′ N.*	*24°06′.4 E.*	*(Ainazi)*		
0	0.1423	0.0279	0.0701	0.5560	0.0200	0.6135
10	0.1420	0.0280	0.0702	0.5568	0.0201	0.6116
20	0.1421	0.0285	0.0702	0.5558	0.0201	0.5920
Mittel	0.1421	0.0281	0.0702	0.5562	0.0201	
St. 2.	*1933. 7.X.*	*57°19′ N.*	*24°04′ E.*	*(Kurmrags)*		
0	0.1415	0.0292	0.0701	0.5548	0.0201	0.6582
10	0.1419	0.0293	0.0702	0.5548	0.0201	0.6529
20	0.1421	0.0294	0.0702	0.5546	0.0201	0.6425
30	0.1425	0.0299	0.0703	0.5540	0.0200	0.6291
40	0.1417	0.0289	0.0702	0.5534	0.0202	0.5656
Mittel	0.1419	0.0293	0.0702	0.5543	0.0201	
St. 3.	*1933. 7.X.*	*57°28′.5 N.*	*23°20′ E.*	*(Mersrags)*		
0	0.1418	0.0296	0.0702	0.5538	0.0200	0.5960
10	0.1418	0.0296	0.0702	0.5538	0.0200	0.5960
20	0.1418	0.0296	0.0702	0.5538	0.0200	0.5960
30	0.1425	0.0299	0.0702	0.5538	0.0200	0.5960
40	0.1422	0.0288	0.0701	0.5532	0.0200	0.5266
Mittel	0.1420	0.0295	0.0702	0.5537	0.0200	
St. 4.	*1933. 22.X.*	*57°43′.7 N.*	*22°06′.6 E.*	*(Irbesche Meerenge)*		
0	0.1415	0.0276	0.0699	0.5531	0.0200	0.4943
10	0.1413	0.0270	0.0699	0.5528	0.0201	0.4427
20	0.1411	0.0270	0.0698	0.5529	0.0201	0.4404
Mittel	0.1413	0.0272	0.0699	0.5529	0.0201	
St. 6.	*1933. 17.X.*	*56°15′.6 N.*	*20°37′.2 E.*	*(Pape)*		
0	0.1409	0.0266	0.0696	0.5530	0.0201	0.4296
10	0.1415	0.0266	0.0696	0.5528	0.0201	0.4278
20	0.1408	0.0264	0.0695	0.5529	0.0200	0.4197
30	0.1412	0.0264	0.0696	0.5529	0.0200	0.4160
Mittel	0.1411	0.0265	0.0696	0.5529	0.0201	
St. 5.	*1933. 18.X.*	*57°20′.5 N.*	*19°56′.5 E.*	*(Gotland)*		
0	0.1409	0.0264	0.0695	0.5530	0.0200	0.4039
20	0.1411	0.0265	0.0696	0.5529	0.0201	0.4038
40	0.1409	0.0265	0.0695	0.5530	0.0201	0.3925
60	0.1409	0.0266	0.0695	0.5529	0.0200	0.3801
80	0.1413	0.0258	0.0694	0.5530	0.0201	0.3376
100	0.1410	0.0249	0.0695	0.5529	0.0201	0.2954
120	0.1412	0.0241	0.0695	0.5528	0.0200	0.2805
140	0.1411	0.0242	0.0695	0.5528	0.0201	0.2812
160	0.1416	0.0244	0.0696	0.5529	0.0202	0.2824
180	0.1409	0.0242	0.0695	0.5528	0.0201	0.2743
200	0.1408	0.0242	0.0695	0.5528	0.0201	0.2718
220	0.1408	0.0242	0.0695	0.5528	0.0201	0.2718
Mittel	0.1410		0.0695	0.5529	0.0201	

Tabelle 10.

m.	$\frac{SO_4''}{Cl'}$	$\frac{Ca''}{Cl'}$	$\frac{Mg''}{Cl'}$	$\frac{Na'}{Cl'}$	$\frac{K'}{Cl'}$	$\frac{A}{Cl'}$
St. 1.	*1934. 28.VI. 57°54'.5 N. 24°14' E. (Ainazi)*					
0	0.1417	0.0302	0.0701	0.5540	0.0199	0.6434
20	0.1416	0.0299	0.0700	0.5538	0.0202	0.6018
Mittel	0.1417	0.0301	0.0701	0.5539	0.0201	
St. 2.	*1934. 10.VI. 57°24'.3 N. 24°08'.8 E (Kurmrags)*					
0	0.1422	0.0299	0.0702	0.5539	0.0201	0.6654
20						0.6293
40	0.1419	0.0289	0.0700	0.5538	0.0201	0.5767
Mittel	0.1421	0.0294	0.0701	0.5539	0.0201	
St. 3.	*1934. 9.VI. 57°30' N. 23°22'.5 E. (Mersrags)*					
0	0.1419	0.0300	0.0702	0.5560	0.0200	0.6229
20						0.5910
40	0.1422	0.0278	0.0700	0.5530	0.0202	0.4819
Mittel	0.1421	0.0289	0.0701	0.5545	0.0201	
St. 3a.	*1934. 9.VI. 57°42'.4 N. 22°52' E. (Roja)*					
0	0.1420	0.0301	0.0701	0.5536	0.0201	0.5920
20	0.1421					0.5772
40	0.1422	0.0282	0.0699	0.5534	0.0200	0.4844
Mittel	0.1421	0.0293	0.0700	0.5535	0.0201	
St. 4.	*1934. 9.VI. 57°41'.6 N. 21°56'.8 E. (Irbesche Meerenge)*					
0	0.1418	0.0300	0.0699	0.5531	0.0201	0.5578
20	0.1417	0.0270	0.0700	0.5529	0.0200	0.4269
Mittel	0.1418	0.0285	0.0700	0.5530	0.0201	
St. 6a.	*1934. 8.VI. 56°50' N. 20°48' E. (Akmenrags)*					
0	0.1411	0.0265	0.0697	0.5530	0.0200	0.4232
40	0.1410	0.0264	0.0695	0.5530	0.0201	0.3969
Mittel	0.1411	0.0265	0.0696	0.5530	0.0201	
St. 6.	*1934. 7.VI. 56°11'.2 N. 20°36' E. (Pape)*					
0	0.1412	0.0265	0.0696	0.5530	0.0201	0.4388
30	0.1410	0.0264	0.0696	0.5531	0.0201	0.4035
Mittel	0.1411	0.0265	0.0696	0.5530	0.0201	
St. 5.	*1934. 9.VI. 57°20' N. 19°57' E. (Gotland)*					
0	0.1410	0.0265	0.0695	0.5530	0.0200	0.3966
60	0.1407	0.0264	0.0695	0.5528	0.0202	0.3802
80	0.1409	0.0253	0.0696	0.5528	0.0200	0.3036
100	0.1411	0.0247	0.0695	0.5529	0.0201	0.2870
120	0.1415	0.0242	0.0695	0.5530	0.0201	0.2780
220	0.1410	0.0242	0.0694	0.5529	0.0201	0.2592
Mittel	0.1410		0.0695	0.5529	0.0201	

nur bis etwa 30 m. vor sich geht, während bei 40 m. das Meerwasser vorherrscht.

Doch auch die obere 30 m.-Schicht ist nicht ganz einheitlich: durch die Abnahme der spezifischen Alkalinität mit zunehmender Tiefe wird bewiesen, dass der Süsswassergehalt an der Oberfläche am grössten ist und nach unten allmählich sinkt. Im Ozean dagegen ist die spezifische Alkalinität beinahe konstant und wächst sogar mit der Tiefe.

Aus Tabelle 9, 10 und 11 lässt sich ersehen, dass die Verhältniszahlen der Gotlandmulde (St. 5), ausser bei Kalzium und der Alkalinität, bis zur grössten Tiefe von 220 m. die gleichen bleiben. Somit nehmen alle Bestandteile, ausser den beiden angeführten, von oben nach unten stetig und gleichmässig zu.

Über den prozentischen Anstieg des Gehalts an Kalzium und Chlor und der Alkalinität, sowie des Verhältnisses von Kalzium zur Alkalinität und Kalziums zu Chlor geben uns, auf Grund der Tabellen 6 und 9 (St. 5), Abbildung 2 und Tabelle 12 Aufschluss.

Abbildung 2 und Tabelle 12 zeigen, dass bis zu einer Tiefe von 60 m. der prozentische Zuwachs des Kalziums grösser ist als der des Chlors; von 80 m. an, wo übrigens auch die Temperatursteigerung beginnt, wächst dagegen der Chlorgehalt stärker an, und zwar bis zu einer Tiefe von 120 m. Von da an bis zum Meeresgrunde bleibt die Abnahme des Kalziumgehalts stehen, und zwischen Kalzium und Chlor tritt ein Gleichgewicht ein.

Diese Verteilung des Kalziums ergibt, dass bei Gotland drei deutlich voneinander unterscheidbare Schichten zu erkennen sind.

Die erste Schicht (bis etwa 70 m.) enthält Wasser einheitlicher Zusammensetzung.

Die zweite Schicht dagegen (von 70 m. bis etwa 110 m.) ist nicht einheitlich. Das Wasser der dritten Schicht (von 110 m. bis zum Meeresgrunde) ist wiederum einheitlich, doch von anderen Eigenschaften als das der oberen Schicht.

Diese dreifache Schichtung lässt sich folgendermassen erklären. Der erhöhte Kalziumgehalt und die grössere Alkalinität der obersten Schicht (0 bis 70 m.) weisen auf eine grössere Menge Süsswasser hin: ihr Wasser stammt aus dem Rigaschen Meerbusen, wo ja eine höhere Alkalinität herrscht als im Bottnischen und Finnischen Meerbusen. Es könnte auffallen, dass von 0 bis etwa 40 m. bedeutend weniger Kalzium vorhanden ist als bei 60 m. Das beruht aber darauf, dass in oberen Schichten eine stärkere Photosynthese vor sich geht, und das Kalziumsplankton bedeutende Mengen an Kalzium verbraucht.

Der mit der Tiefe zunehmende Salzgehalt (von 0 bis 220 m. um 73.55 %) wird durch den Zustrom von salzhaltigerem Wasser aus der Nordsee durch das Kattegat bedingt; Wasser aus dem Rigaschen, Bottnischen und Finnischen Meerbusen könnte einen solchen Einfluss nicht ausüben, da es durchweg ärmer an Salzen ist.

In etwa 80 m. Tiefe beginnt eine Wasserschicht, welche durch Mischung des Wassers der oberen und unteren Schichten entstanden ist: das schwerere, salzhaltigere Wasser der Nordsee ergiesst sich durch das

Tabelle 11.

m.	$\frac{SO_4''}{Cl'}$	$\frac{Ca''}{Cl'}$	$\frac{Mg''}{Cl'}$	$\frac{Na'}{Cl'}$	$\frac{K'}{Cl'}$	$\frac{A'}{Cl'}$	$\frac{B}{Cl'}$
St. 1.	*1934. 14.XI. 57°50'.5 N. 24°04' E. (Ainazi)*						
0	0.1421	0.0290	0.0702	0.5541	0.0199	0.6154	0.000279
20	0.1420	0.0291	0.0699	0.5539	0.0200	0.6119	0.000281
Mittel	0.1421	0.0291	0.0701	0.5540	0.0200		0.000280
St. 2.	*1934. 11.X. 57°19'.2 N. 24°05'.5 E. (Kurmrags)*						
0	0.1419	0.0288	0.0700	0.5540	0.0199	0.6252	0.000282
20						0.6204	
40	0.1421	0.0291	0.0702	0.5538	0.0199	0.5456	0.000278
Mittel	0.1420	0.0290	0.0701	0.5539	0.0199		0.000280
St. 3.	*1934. 11.X. 57°28'.6 N. 23°20' E. (Mersrags)*						
0	0.1418	0.0290	0.0700	0.5537	0.0200	0.6188	0.000278
20						0.5932	
40	0.1419	0.0287	0.0701	0.5532	0.0200	0.5268	0.000280
Mittel	0.1419	0.0289	0.0701	0.5535	0.0200		0.000279
St. 3a.	*1934. 17.X. 57°42'.3 N. 22°52'.2 E. (Roja)*						
0	0.1420	0.0290	0.0699	0.5535	0.0199	0.5637	0.000278
20						0.5380	
40	0.1419	0.0289	0.0702	0.5537	0.0200	0.5298	0.000278
Mittel	0.1420	0.0290	0.0701	0.5536	0.0200		0.000278
St. 4.	*1934. 17.X. 57°41'.2 N. 21°49'.7 E. (Irbesche Meerenge)*						
0	0.1414	0.0270	0.0699	0.5530	0.0199	0.4188	0.000252
20	0.1415	0.0271	0.0700	0.5530	0.0199	0.4209	0.000252
Mittel	0.1415	0.0271	0.0700	0.5530	0.0199		0.000252
St. 4a.	*1934. 17.X. 57°33' N. 21°02' E. (Ventspils)*						
0	0.1413	0.0265	0.0696	0.5529	0.0200	0.4242	0.000252
20	0.1414	0.0266	0.0696	0.5530	0.0199	0.4242	0.000252
Mittel	0.1414	0.0266	0.0696	0.5530	0.0200		0.000252
St. 5.	*1934. 18.X. 57°20' N. 19°57' E. (Gotland)*						
0	0.1411	0.0265	0.0696	0.5529	0.0199	0.4109	0.000249
80	0.1409	0.0257	0.0695	0.5528	0.0200	0.3230	0.000250
120	0.1410	0.0242	0.0694	0.5530	0.0199	0.2835	0.000250
160						0.2761	
200	0.1411	0.0243	0.0696	0.5527	0.0199	0.2711	0.000248
Mittel	0.1410		0.0695	0.5529	0.0199		0.000249
St. 6.	*1934. 2.XI. 56°06'.8 N. 20°32' E. (Pape)*						
0	0.1412	0.0265	0.0696	0.5529	0.0199	0.4074	0.000250
30	0.1411	0.0266	0.0695	0.5530	0.0199	0.4074	0.000249
Mittel	0.1412	0.0266	0.0696	0.5530	0.0199		0.000250
St. 6a.	*1934. 2.XI. 56°58' N. 20°45'.5 E. (Akmenrags)*						
0	0.1411	0.0265	0.0696	0.5530	0.0199	0.4030	0.000250
20						0.4030	
40						0.4030	
60	0.1411	0.0266	0.0695	0.5531	0.0200	0.4030	0.000252
Mittel	0.1411	0.0266	0.0696	0.5531	0.0200		0.000251

Kattegat als Unterschicht in das Baltische Meer, während das leichtere süssere Wasser des Baltischen Meeres auf demselben Wege in die Nordsee strömt. Dieses Mischwasser erstrekt sich bis zu einer Tiefe von etwa 110 m. Der verhältnismässige Kalziumgehalt sinkt, da ja das vom offenen Meere zuströmende Wasser ein anderes Verhältnis von Kalzium zu Chlor aufweist. Zur Annahme, dass Kalziumsalze ausgefällt würden, fehlt daher jeder Grund. Die Temperatur, die bis 80 m. mit der Tiefe stetig abnimmt, fängt plötzlich an zu steigen, der Sauerstoffgehalt sinkt um etwa 50 %, und die Menge der Kationen und

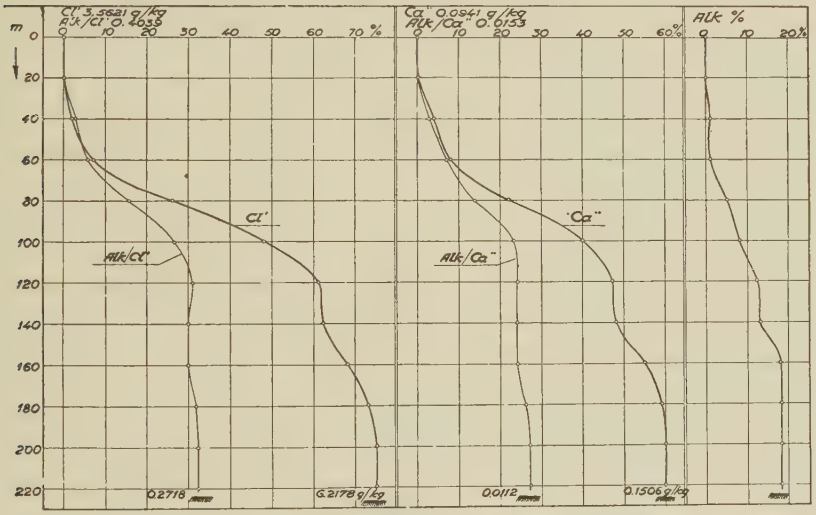

Abbildung 2.

Tabelle 12.

Der prozentische Anstieg des Kalziums und Chlors in verschiedenen Tiefen.

m.	(A—Ca") %	A %	Anstieg Ca" %	Cl' %	(Ca"—Cl') %
0	0	0	0	0	0
20	— 0.21	0	0.21	0.05	+ 0.16
40	— 3.07	0.97	4.04	3.91	+ 0.13
60	— 7.00	0.97	7.97	7.29	+ 0.68
80	— 17.78	4.86	22.64	25.45	— 2.81
100	— 31.50	8.24	39.74	48.00	— 8.26
120	— 35.00	11.65	46.65	60.79	— 14.14
140	— 35.73	12.62	48.35	61.76	— 13.41
160	— 37.67	17.48	55.15	68.04	— 12.89
180	— 41.18	17.48	58.66	73.01	— 14.35
200	— 42.56	17.48	60.04	74.55	— 14.51
220	— 42.56	17.48	60.04	74.55	— 14.51

Anionen ändert sich: alles Anzeichen dafür, dass sich hier zwei verschiedene Strömungen begegnen. Unterhalb 120 m. befindet sich das Wasser der Nordsee.

Schlussfolgerungen.

Die Sulfate, das Kalzium, Magnesium, Natrium, Kalium und Bor verhalten sich zu Chlor wie folgt:—

Im Rigaschen Meerbusen.

$SO_4''/Cl' = 0.1420$
$Ca''/Cl' = 0.02942$ (im Frühling und Frühsommer)
„ $= 0.02896$ (Im Sommer und Herbst)
$Mg''/Cl' = 0.07015$
$Na'/Cl' = 0.5543$
$K'/Cl' = 0.0200$
$B/Cl' = 0.000279$

In der Irbeschen Meerenge.

$SO_4''/Cl' = 0.1415$
$Ca''/Cl' = 0.0278$
$Mg''/Cl' = 0.06995$
$Na'/Cl' = 0.5530$
$K'/Cl' = 0.0200$
$B/Cl' = 0.000252$

Im Baltischen Meere.

$SO_4''/Cl' = 0.1411$ (an der lettländischen Küste)
„ $= 0.1410$ (in der Gotlandmulde)
$Ca''/Cl' = 0.0265$ (von 0 bis 70 m.)
„ $= 0.0256$ (in etwa 80 m.)
„ $= 0.0248$ (in etwa 100 m.)
„ $= 0.0242$ (von 120 m. bis zum Meeresgrunde)
$Mg''/Cl' = 0.0695$
$Na'/Cl' = 0.5529$
$K'/Cl' = 0.0200$
$B/Cl' = 0.000250$

Die ursprüngliche Knudsensche Formel

$$S\,{}^0/_{00} = 0.030 + 1.8050.Cl$$

wäre folgendermassen zu korrigieren:
für den Rigaschen Meerbusen $S\,{}^0/_{00} = 0.130 + 1.8050.Cl$
für das Baltische Meer $S\,{}^0/_{00} = 0.115 + 1.8050.Cl$.

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Eine Methode zur exakten quantitativen Bestimmung von Zooplankton.

Mit allgemeinen Bemerkungen über quantitative Planktonarbeiten.

Von

E. Steemann Nielsen.

BEI Untersuchungen über die Produktion im Meere sind exakte quantitative Bestimmungen des Planktons absolut notwendig. Bei Zooplanktonorganismen sind solche Bestimmungen jedoch bis jetzt nur in geringem Grade ausgeführt. Gewöhnliche "quantitative" Netze wie z. B. das Nansen-Netz sind nicht einmal zuverlässig, wenn man nur relative Werte erzielen will, da das Filtriervermögen sich in hohem Masse nach Art und Menge des zu fischenden Planktons ändert. Vor allem ist dies bei den feinmaschigen Netzen der Fall.

Während man aus der Oberfläche wirklich quantitative Fänge ziemlich leicht erhalten kann, indem man das Oberflächenwasser entweder mit einem Eimer oder mittels einer Pumpe an Bord bringt und hier bestimmte Wassermengen filtriert (*vide* Hentschel 1925), verhält es sich ganz anders, wenn man auch das Plankton unterhalb der Oberfläche erfassen will. Verschiedene Wege sind hierbei eingeschlagen worden.

Lohmann (1902) führte eine Pumpenmethode ein; er liess einen Gummischlauch in die gewünschte Tiefe hinunter, und das Wasser wurde dann mittels einer Pumpe hinaufgesaugt und an Bord filtriert. Bei Zooplanktonuntersuchungen lässt sich diese Methode aber nur bei ganz geringen Tiefen benutzen, da der Schlauch in diesem Falle beträchtliche Dimensionen haben muss und darum zu schwer und unhandlich wird, wenn es sich auch nur um Tiefen von 50 m. handelt. Auf der "Meteor" Expedition nach dem südlichen Atlantischen Ozean wurde diese Methode versucht, aber bald wieder aufgegeben (Hentschel 1932).

Pettersson (1926) konstruierte einen Fangapparat mit einem angeschlossenen Pumpenmechanismus, wobei registrierbare Wassermengen *in situ* filtriert wurden, nachdem der Apparat in die gewünschte

Tiefe hinuntergelassen war. Dieser im Prinzip ideale Fangapparat lässt sich jedoch wegen seines komplizierten Baues in Praxis nur schwer benutzen.

Harvey (1934) hat ein Vertikalnetz konstruiert, das die Menge des vom Netze filtrierten Wassers registriert. Dieses Netz hat sich in Praxis gut bewährt. Es lässt sich auch als Schliessnetz benutzen, wodurch es möglich wird, auch tiefere Wasserschichten quantitativ zu durchfischen. Zur Bestimmung der Planktonmenge unter einem bestimmten Oberflächenareal ist das Netz von Harvey wohl geeignet. Wenn jedoch Phytoplankton in grossen Mengen vorhanden ist, wird man meiner Meinung nach leicht ein falsches Bild über die Zooplanktonmenge erhalten. Besonders ist dies der Fall, wenn schleimige Algenarten wie z. B. *Phaeocystis pouchetii* reichlich vorhanden sind. Während des Fanges ändert sich dann das Filtriervermögen des Netzes in hohem Grade (cpr. Kokubo und Tamara 1931). Es wird deshalb verhältnismässig weniger aus dem oberen Teil der Wassersäule als aus dem unteren gefischt. Da die vertikale Verteilung der Zooplanktonten auch innerhalb kleiner Distanzen oft sehr ausgeprägt ist, wird man wahrscheinlich öfters keine repräsentativen Planktonwerte der Wassersäule erhalten.

Wahrscheinlich eignet sich Harvey's registrierbares Vertikalnetz nicht für feinere Untersuchungen über die vertikale Verteilung der Planktonten. Harvey durchfischt 20—40 m., um eine repräsentative Probe zu erhalten. Man muss durchaus Hjort und Ruud (1925) beistimmen: "that the ideal quantitative method of investigating small plankton animals must aim at the filtration of a sample of water or of water of a known volume from a definite depth."

Hentschel (1932 und 1933) hat eine Methode ausgearbeitet, wonach das Plankton in 2 oder 4 l. Meerwasser in grossen Glaszylindern in kardanischer Aufhängung zum Sedimentieren gebracht wird. Nachdem das überstehende Wasser vorsichtig abgehebert ist, lässt man das Plankton in eine Zählkammer überführen. Als Einwendung gegen diese Methode ist anzuführen, dass man hierbei meistens zu wenig Plankton erhält, um eine statistische Behandlung durchzuführen. Nur wenn eine sehr grosse Menge von Proben in dieser Weise in einem Gebiet gesammelt sind, wie es bei den Oberflächenproben der "Meteor" Expedition im südlichen Atlantischen Ozean der Fall war, erhält man ein brauchbares Bild über die quantitative Verteilung der Planktonten.

Hjort und Ruud (1927) haben versucht, grosse Wasserschöpfer für 100 l. zu konstruieren, um damit an Bord das Plankton aus den Wasserproben aus verschiedenen Tiefen herausfiltrieren zu können. Es ist ihnen jedoch nie gelungen, ein handliches Modell zu erzielen. Solche grossen Wasserschöpfer aus Metall sind schwer und darum für Arbeiten bei auch nur einigermassen bewegter See zu gefährlich.

Im Planktonlaboratorium der dänischen Kommission für Meeresforschung ist nun vom Verfasser ein Wasserschöpfer aus Segeltuch für

Fig. 1. Der Fangbeutel in zusammengeklapptem Zustande am Doppeltauslöser hängend.

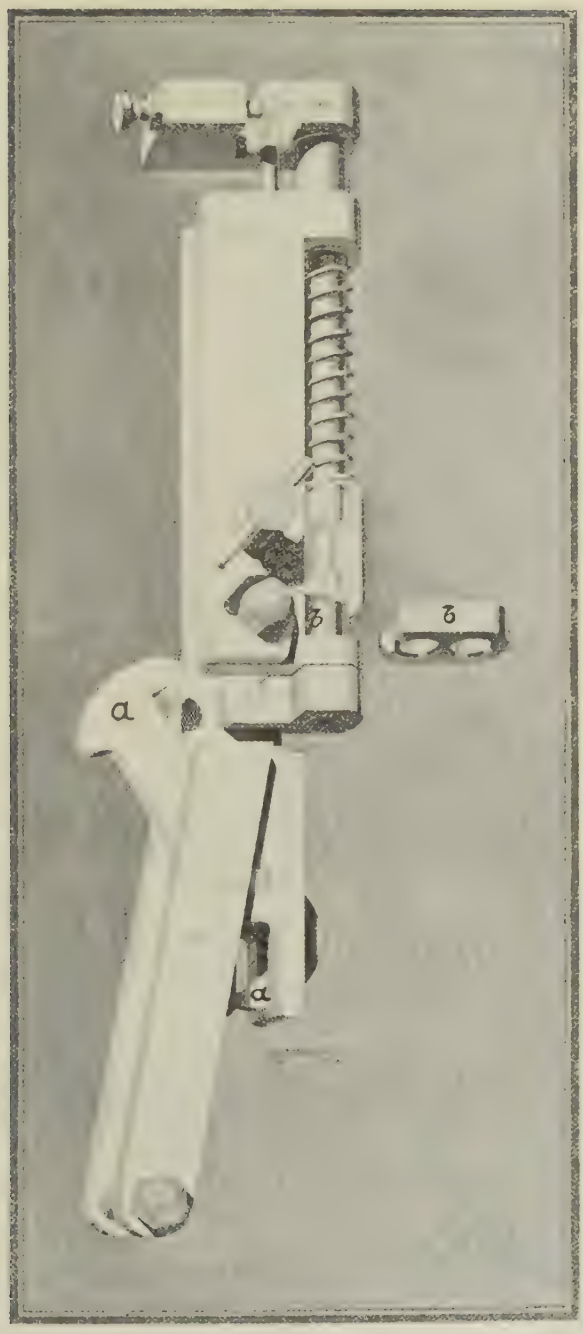

Abb. 2. Doppeltauslöser nach Ostenfeld und Jespersen (1924) Fig. 6. In dieser Arbeit ist eine nähere Beschreibung gegeben. Das kleine Lot bewirkt eine Auslösung bei *a*, das grosse Lot bei *b*.

100 l. Wasser konstruiert worden, der im Frühling 1935 auf einer Expedition nach Island mit dem M/S "Thor" durchgeprüft wurde. Die Kosten dieser Expedition wurden von dem "Kaptajn Alf Trolle og Hustrus Legat til Minde om Danmark-Expeditionen 1906—1908" getragen.

Ein grosser Beutel aus Segeltuch[1]) — Länge 1.25 m. und Durchmesser 0.5 m. — unten konisch zugespitzt und hier mit einem schweren Eisengewicht und einem Hahn versehen, wird von drei galvanisierten Eisenringen ausgespannt (s. Abb. 3). Vor dem Gebrauch wird der Beutel zusammengeklappt und an einen Doppeltauslöser befestigt (s. Abb. 1). Dieser Doppeltauslöser entspricht dem, der bei Ostenfeld und Jespersen (1924) beschrieben ist (s. Abb. 2). Ein innerhalb der Mündung des Beutels angebrachter Eisenring (Durchmesser 31 cm.) und ein darauf befestigter Bügel halten den Beutel zusammengeklappt (s. Abb. 1).

Der Doppeltauslöser wird an der hydrographischen Wire (4 mm.) befestigt und der ganze Apparat in die gewünschte Tiefe hinuntergelassen. Bevor man ihn hinunterlässt, muss man die Luft aus dem Hohlraume unterhalb des Fangapparates entweichen lassen. Wenn der Apparat in der gewünschten Tiefe angelangt ist, wird ein kleines Lot hinuntergelassen. Hierdurch entfaltet sich der Beutel (s. Abb. 3) und füllt sich mit Wasser. Etwa 10 Sekunden nachdem das kleine Lot hinuntergelassen worden ist, wird ein grosses Lot hinuntergesenkt; hierdurch wird bewirkt, dass der Beutel sich oben zusammenschnürt (s. Abb. 4). Jetzt wird der Fangapparat an die Oberfläche heraufgeholt. Da die hydrographische Wire den gefüllten Fangapparat nicht ausserhalb des Wassers tragen kann, wird eine starke Hanfleine an dem Apparat befestigt, mit der er nun hochgezogen wird; ein kleines Netz (Durchmesser 30 cm. und Seide Nr. 25) wird jetzt unter dem Beutel angebracht (s. Abb. 5). Der Hahn wird geöffnet und das Wasser wird durch die feine Seide filtriert.

Bei unruhigem Wetter wird der Fangapparat an der Reling befestigt. Nach Beendigung der Filtration wird das abfiltrierte Plankton quantitativ in kleine Flaschen überführt und hier konserviert. Inzwischen ist der Fangapparat wieder zusammengeklappt und in eine neue Tiefe hinuntergelassen.

Die Zeitdauer für einen Fang von 25 m. beträgt z. B. nur 8 Minuten und man braucht nur die Hilfe eines Mannes. Der Apparat lässt sich auch bei einigermassen bewegter See benutzen[2]). Bei sehr starkem Strom empfiehlt es sich, in der Verlängerung des Hahnes ein Bleigewicht zu befestigen.

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[1]) Der obere Teil des Beutels wird aus nicht imprägniertem Material hergestellt, der untere Teil dagegen aus einem kräftigeren, imprägnierten Material. Der Beutel wird mit einem dünnen Anstrich aus einer Mischung von Leinöl und Firnis versehen.

[2]) Die grösste Gefahr des Misslingens liegt darin, dass die Leine, die den Beutel oben zusammenschnürt und die darum verhältnismässig dünn sein muss, bei sehr bewegter See zerreisst. Diese Leine ist deshalb an einem starken Seil befestigt, das sowohl am Auslöser als auch am Beutel festgemacht ist (s. Abb. 4). Beim Zerreissen der dünnen Leine verhindert das dicke Seil, dass der Beutel verloren geht.

Fig. 3. Das kleine Lot hat den ersten Teil des Mechanismus ausgelöst. Der Beutel hat sich ausgefaltet.

Fig. 4. Das grosse Lot hat den zweiten Teil des Mechanismus ausgelöst. Der Beutel ist oben zusammengeschnürt worden.

Die hier besprochene Methode ist zum quantitativen Fange der kleineren Zooplanktonten von der Grösse von Copepodennauplien bis zu der von erwachsenen Copepoden berechnet. Grössere Planktonten sind zu spärlich vorhanden und können wohl auch dem Fangbeutel entgehen. Bei den kleineren Arten ist dies kaum möglich, da die verhältnismässig grosse Wassermenge im Laufe von wenigen Sekunden in den Fangbeutel hinein strömt, der dann sofort geschlossen wird.

Hentschel (1932) gibt an, dass die Copepodennauplien zum Teil durch die Maschen der Seide Nr. 25 schlüpfen können. Zweifellos ist dies bei verschiedenen tropischen Arten der Fall. Die Nauplien, selbst im Stadium 1, sind jedoch bei den nordischen Copepoden alle über 70 µ im Durchmesser und werden demnach alle von der Seide Nr. 25 zurückgehalten. Hentschel (1932) führt auch an, dass die kleinen Nauplien teilweise beim Filtrieren in den Maschen der Seide hängen bleiben; er meint aber doch, dass dies bei sorgfältiger Arbeit einigermassen verhindert werden kann. Die beste Methode, um ein Hängenbleiben der kleinsten Planktonten in den Maschen der Seide zu verhindern, ist nach meiner Meinung ein kräftiges Abspülen der Wände des Netzes von aussen. Etwaige hängengebliebene kleine Planktonten werden in dieser Weise leicht in den Sammeleimer hinuntergebracht.

Wenn die 100 l. durch die Seide des Netzes filtriert sind, erhält man einen Rückstand aus Phytoplankton und Zooplankton. Ist das Phytoplankton nur spärlich vorhanden, lässt sich die ganze Probe später in eine 30 ccm. Röhrenkammer nach Utermöhl überführen, worauf die Zooplanktonten im umgekehrten Mikroskop gezählt werden. Ist dagegen viel Phytoplankton vorhanden, wird nur ein so grosser Teil der Probe in die Röhrenkammer überführt, dass eine genaue Zählung möglich ist. Eine Teilung der Probe lässt sich am besten mittels einer Stempelpipette von Apstein (s. Apstein 1896) ausführen. Meistens sind die Nauplien und die anderen ganz kleinen Zooplanktonten in so grosser Menge vorhanden, dass die Zahlwerte für diese schon hierbei genügen. Ist dies nicht der Fall, ist es notwendig, den Inhalt von mehreren Röhrenkammern zu zählen. Der Rest der Probe wird durch eine weitmaschige Gaze filtriert (z. B. Nr. 9 oder Nr. 3). Die Hauptmasse des Phytoplanktons geht hierbei durch die Maschen und eine Zählung der Zooplanktonten wird möglich. Organismen, die durchweg grösser als 160 µ im Durchmesser sind, können nach einem Filtrieren durch Seide Nr. 9 gezählt werden, Organismen durchweg grösser als 300 µ im Durchmesser nach Filtrieren durch Seide Nr. 3. Je grösser die Maschen der Seide sind, um so effektiver wird das Phytoplankton entfernt.

Eine solche Zählung ist niemals sehr zeitraubend. Wenn nicht der Fangbeutel mit einer Mischung von Leinöl und Firnis behandelt ist, werden kleinere Mengen winziger Fasern vom Segeltuch abgegeben, die sich in der Zählkammer zusammenballen und deshalb störend auf die Zählung wirken können.

Es fragt sich nun, ob das Zooplankton aus 100 l. in genügender

Fig. 5. Der Fangapparat ist an Bord geholt. Der Hahn ist geöffnet und ein Netz aus Seide Nr. 25 unten angebracht.

Menge für statistische Zwecke vorhanden ist. In den nordischen Fahrwassern ist dies jedenfalls durchgehends der Fall. Die umstehenden Listen der Zählungen des Isländischen Planktons zeigen, dass die Zahlenwerte genügend gross sind, obwohl die Produktion der Zooplanktonten sich nur im allerersten Anfang befand. Z. B. hatte die Produktion von Copepodennauplien bei Keflavig in dem südlichen Teil des Faxefjords noch nicht eingesetzt. Ferner zeigen die Untersuchungen von Hentschel (1933) bei Island im Spätsommer, dass die Metazoen, die aus 2 l. Oberflächenwasser bestimmt wurden, in einer Anzahl von durchschnittlich ca. 3000 pro 100 l. gefunden wurden. Im Englischen Kanal zeigen die Untersuchungen von Harvey, Cooper, Lebour und Russell, dass die Zooplanktonten im März — Oktober auch durchschnittlich in einer Menge von ca. 3000 pro 100 l. vorhanden sind. Im Winter sind sie bedeutend spärlicher. Im Januar wurden nur einige hundert Metazoen pro 100 l. gefunden.

Apstein (1906) hat den Inhalt pro Volumeneinheit nach den Netzfängen der Deutschen Terminfahrten in der Nord- und Ostsee berechnet. Die Zahlen sind wohl durchweg etwas zu hoch, aber wahrscheinlich doch von einigermassen richtiger Grössenordnung.

Tabelle 1.

Durchschnittswerte für Metazoen pro 100 l. der oberen Wasserschichten. Nach Apstein (1906) berechnet.

	Ostsee	Nordsee
Februar	2,000	12,000
Mai	10,000	3,000
August	5,000	3,000
November	2,000	500

In den oligotrophen tropischen Teilen der Ozeane und in grösseren Meerestiefen ist der Gehalt an Zooplankton in 100 l. wohl meistens zu gering, um statistische Forderungen zu befriedigen.

Wenn die Planktonmenge aus relativ kleinen Wassermengen bestimmt wird, muss es eine absolute Forderung sein, dass die Planktonten regelmässig verteilt sind. Bei den kleineren Zooplanktonten ist dies im grossen und ganzen wohl immer der Fall. Bei Island wurden einige Versuche angestellt, die auch dies bestätigen. Die 3 Parallelfänge bei Keflavig aus 10 m. zeigen einen gut übereinstimmenden Gehalt an Plankton (s. Tabelle 2); dasselbe ist der Fall bei den zwei Parallelfängen aus 25 m. Tiefe an der Mündung des Hvalfjords (s. Tabelle 3).

Dagegen sind die Unterschiede in der Menge der verschiedenen Organismen auch innerhalb relativ kleiner vertikaler Unterschiede meistens bedeutend (s. Tabellen 3—5). Bei Untersuchungen über die vertikale Verteilung der Zooplanktonten ist die hier beschriebene Fangmethode sehr geeignet. Um ein zuverlässiges Bild von der Planktonmenge unter einem bestimmten Oberflächenareal zu erhalten, ist es nötig, auf jeder Station Fänge mit relativ kleinen vertikalen Abständen zu machen — in den oberen Wasserschichten jedenfalls alle 10 m. Dies

nimmt natürlich bedeutend längere Zeit in Anspruch, als wenn man nur einen einzigen Fang mit einem quantitativen Vertikalnetz macht. Es ist aber reichlich die Mühe wert!

Netze aus Seide Nr. 25 werden immer noch bei quantitativen Phytoplanktonuntersuchungen benutzt (s. z. B. Harvey, Cooper, Lebour und Russell 1935). In derselben Weise könnte natürlich auch der hier besprochene Fangbeutel benutzt werden. Das Wasser wird ja auch hier durch Seide Nr. 25 filtriert. Ich hoffe jedoch, dass dies nie geschehen möge! Nur ein Bruchteil des Phytoplanktons wird von der Seide zurückgehalten. Nicht nur gehen sämtliche Nannoorganismen durch die Maschen, sondern auch eine grosse Anzahl von Mikroorganismen schlüpfen mehr oder weniger hindurch. Organismen unter 50 μ im Durchmesser gehen zum grossen Teil durch die Maschen! Netzfänge geben freilich manchmal ein einigermassen gutes relatives Bild der wirklichen Phytoplanktonverhältnisse, aber bei weitem nicht immer. Auf dem offenen Ozean machen die Organismen, die vom Netz gefasst werden, meistens nur einen ganz minimalen Prozentteil der ganzen Planktonmenge aus. In Küstengebieten — besonders in offenen — verändert sich das Verhältnis Mikroplankton : Nannoplankton oft in ausserordentlich hohem Masse. Quantitative Phytoplanktonbestimmungen nach dem Netzplankton sind zu vergleichen mit einer Zählung der Menschen, wobei nur Individuen, die z. B. grösser als 180 cm. sind, in Betracht kamen. Ich glaube nicht, dass man die Einwohnerzahl z. B. von Dänemark und Griechenland in der Weise vergleichen kann!

Noch unsicherer wird eine Phytoplanktonbestimmung, wenn beim Filtrieren gröbere Seide benutzt wird, wie es bei dem "continuous plankton recorder" von Hardy (1935) der Fall ist. Die Fadenanzahl der Gaze ist hier 60 pro 14 mm. Organismen unter ca. 150 μ im Durchmesser gehen demnach durch die Maschen. Von den Phytoplanktonorganismen werden nur ganz wenige Riesenarten gefangen (zufällig wird natürlich immer eine kleine Anzahl der kleineren Organismen zurückgehalten). Bei den Untersuchungen von Hardy in der Nordsee sind es darum unter den Diatomeen die grossen Arten *Rhizosolenia styliformis* und *Biddulphia sinensis,* die vorzugsweise gefangen werden. Detaillierte Untersuchungen über die Verbreitung dieser Arten sind natürlich wertvoll. Während *Biddulphia sinensis* eine typisch neritische Art ist, ist das Auftreten der ozeanischen Art *Rhizosolenia styliformis* in der Nordsee ein Kriterium für Atlantisches Wasser, das durch die Färö-Shetland-Rinne in die Nordsee hereingeströmt ist.

Hardy versucht aber auch, die Totalmenge der Phytoplanktonten, die mit seinem Planktonregistrator gefangen werden, als ein Mass der Phytoplanktonproduktion zu benutzen (s. Fig. 3 bei Hardy 1935). Es wird ausdrücklich auf Seite 37 betont: "Fig. 3 shows examples of the changes in production of Phytoplankton etc." Eine solche Verwertung des Materials des Planktonregistrators halte ich für ganz verfehlt. In noch höherem Masse als bei den Netzen mit feinmaschiger

Gaze wird nur die Menge einer minimalen Anzahl der im Meere anwesenden Arten bestimmt. Eine Abwesenheit dieser Arten in den Fängen des Planktonregistrators braucht durchaus nicht zu bedeuten, dass das Phytoplankton als ganzes betrachtet arm ist; es kann im Gegenteil vielleicht sehr reich sein! Während die Kurven der einzelnen Phytoplanktonorganismen bei Hardy wertvoll sind, sind dagegen die Kurven der Totalmenge der Phytoplanktonorganismen nichtssagend. Einen Ausdruck für die Phytoplanktonproduktion geben sie nicht, und pflanzengeographisch sagen sie auch nichts, da Arten mit ganz verschiedener ökologischer Valenz zusammengeschlagen sind.

Man versteht sehr wohl, dass verschiedene Forscher neue Wege suchen, um die Phytoplanktonproduktion zu messen. Die Zählresultate, die mittels der Zentrifuge oder des umgekehrten Mikroskops erzielt werden, sind wegen der grossen Unterschiede in der Grösse der Organismen sehr schwer miteinander zu vergleichen, besonders für Nichtspezialisten. Dazu sind diese Methoden auch zeitraubend. Eine einfache Methode, wie sie z. B. Harvey (1934) beschreibt, um die Klorophylmenge des Netzplanktons zu bestimmen, ist bestechend, aber sehr riskant. Man kann nie wissen, ob man die Klorophylmenge z. B. in $^{9}/_{10}$ oder $^{1}/_{100}$ bestimmt hat. Da es vorläufig nicht möglich ist, die Klorophylmenge in den kleinen Mengen Plankton, die immer bei Sedimentationsmethoden erzielt werden, zu bestimmen, ist es vorzuziehen, gebundenen Kohlenstoff oder den Stickstoff des Planktons zubestimmen. Methoden sind jetzt ausgearbeitet, die es ermöglichen, diese Stoffe im Plankton von wenigen Hundert ccm. Meerwasser zu bestimmen (vide v. Brand 1935).

Ferner geben Stoffwechselversuche mit Meerwasser mit dem natürlichen Gehalt an Phytoplankton in verschiedenen Tiefen im Meere eine vorzügliche Methode, wirkliche "Produktionswerte" zu erzielen (s. z. B. Steemann Nielsen 1932). In den meisten Gebieten ist diese Methode jedoch nur in der Zeit des Frühlingsmaximum mit Sicherheit zu verwenden. Ein Versuch, diese Methode bei einer Untersuchung über die jährliche Produktion von Phytoplankton in einem dänischen Gewässer zu benutzen, scheiterte z. B. In eutrophen Gebieten, wie z. B. an der Südküste von Island, ist diese Methode dagegen durch die ganze Produktionssaison anwendbar.

Bei quantitativen Arbeiten sowohl mit Zooplankton wie auch mit Phytoplankton muss man sich bestreben, wirklich exakte Methoden anzuwenden, wenn sie auch mehr zeitraubend sind. Eine zuverlässige Arbeit, die auf Grundlage von exakten Messungen zusammengestellt ist, ist mehr wert als drei Arbeiten, die vielleicht in derselben Zeit mit unsicheren Methoden ausgeführt sein könnten!

Der hier beschriebene Fangapparat für Zooplankton ist vom Konservator H. J. Nielsen, Polyteknisk Læreanstalt Kopenhagen, hergestellt. In verschiedener Weise sind Dr. P. Jespersen und der Führer des M/S "Thor", Kapitän P. Gjessing, behilflich gewesen. Diesen Herren und Herrn Kapitän Alf Trolle, der die Expedition ermöglichte, spreche ich meinen besten Dank aus.

Tabelle 2.

Der Gehalt an Metazoen pro 100 l. in drei Parallelfängen aus 10 m. bei Keflavig, Island (64°00′ N., 22°32′ W.), 11. V. 1935, vormittags.

	A	B	C
Nauplien von Copepoden	11	17	11
Copepoden	23	28	22
Nauplien von Cirripedien	4830	5550	4100
Cyprisstadium von Cirripedien .	2	5	3
Decapodlarven	4	3	5
Würmerlarven	13	20	6
Medusen	1		
Fischeier	3	7	9

Tabelle 3.

Der Gehalt an Metazoen pro 100 l. an der Oberfläche und in zwei Parallelfängen aus 25 m. Tiefe an der Mündung des Hvalfjord, Island (64°18′ N., 21°55′ W.), 17. V. 1935, vormittags.

	0 m.	25 m. A	25 m. B
Nauplien von Copepoden	707	1015	1295
Copepoden	63	434	469
Nauplien von Cirripedien	84	63	91
Cyprisstadium von Cirripedien .		38	56
Decapodlarven	1	4	4
Cladoceren		3	5
Würmerlarven	1	28	21
Schneckenlarven		7	21
Medusen		3	3
Fischlarven		1	

Tabelle 4.

Der Gehalt an Metazoen pro 100 l. aus 0, 10 und 25 m. Tiefe bei Keflavig, Island (64°00′ N., 22°32′ W.), 14. V. 1935, vormittags.

	0 m.	10 m.	25 m.
Nauplien von Copepoden	6	3	95
Copepoden	23	25	21
Nauplien von Cirripedien	31	36	1690
Cyprisstadium von Cirripedien .	3	5	
Decapodlarven		2	5
Würmerlarven	9	8	11
Echinidenlarven	1		
Schneckenlarven			40
Fischeier	5	4	1
Fischlarven		2	

Tabelle 5.

Der Gehalt an Metazoen pro 100 l. aus 0, 10 und 25 m. Tiefe im inneren Teil des Hvalfjord, Island (64°22′ N., 21°31′ W.), 18. V. 1935, vormittags.

	0 m.	10 m.	25 m.
Nauplien von Copepoden	38	1536	3234
Copepoden	39	440	3690
Nauplien von Cirripedien	5	76	84
Cyprisstadium von Cirripedien .	1	2	1
Cladoceren		36	21
Decapodlarven			7
Würmerlarven		3	42
Schneckenlarven		2	35
Muschellarven			7
Medusen			3
Fischeier	2		

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Some Meteorological Observations.

By

Lyman D. Phifer and C. L. Utterback,
Oceanographic Laboratory, University of Washington, Seattle.

ALTHOUGH a considerable amount of the meteorological data obtained by the Oceanographic Laboratory of the University of Washington appears in the various reports of the laboratory it is probable that such data will be of interest to other investigators and of value to them for purposes of comparison. The following table and graphs show the results of observations of air temperature, surface temperature of sea water, total solar radiation and elapsed time between sunrise and sunset at the field laboratory in Friday Harbor for the year 1934.

Instruments. The air temperatures were measured with a Tycos thermometer reading to 0.05° C. The sea water temperatures were measured with a Richter and Weise reversing thermometer. The intensity of solar radiation was measured with an Epply thermo-electric pyrheliometer which is a modified form of the United States Weather Bureau type and which has been described by Kimball[1]), of the Weather Bureau. The pyrheliometer was connected to an Engelhard Type S-1 recording micro-ammeter and was calibrated by the United States Department of Agriculture, Weather Bureau. The energy of total solar radiation, direct plus diffuse, required for one scale division on the record sheet was at a rate of 0.0145 gram calories per minute per square centimetre of horizontal surface, while that required for a full scale deflexion of the micro-ammeter was at a rate of 1.45 gm. cal. per min. per sq. cm.

The instruments were mounted in a specially constructed house on the observation pier. The pyrheliometer was on the top of the house

[1]) Herbert H. Kimball, U. S. Department of Agriculture, W. B. 1051, Circular Q, 1931.

and the recorder and the thermometers were inside. The thermometers were screened to shield them from radiation and to permit free passage of air over the bulbs. The screen was so constructed that its walls were highly reflecting and of good non-conducting materials. The construction permitted free circulation of air and maintained a good approximation to the true temperature of the air.

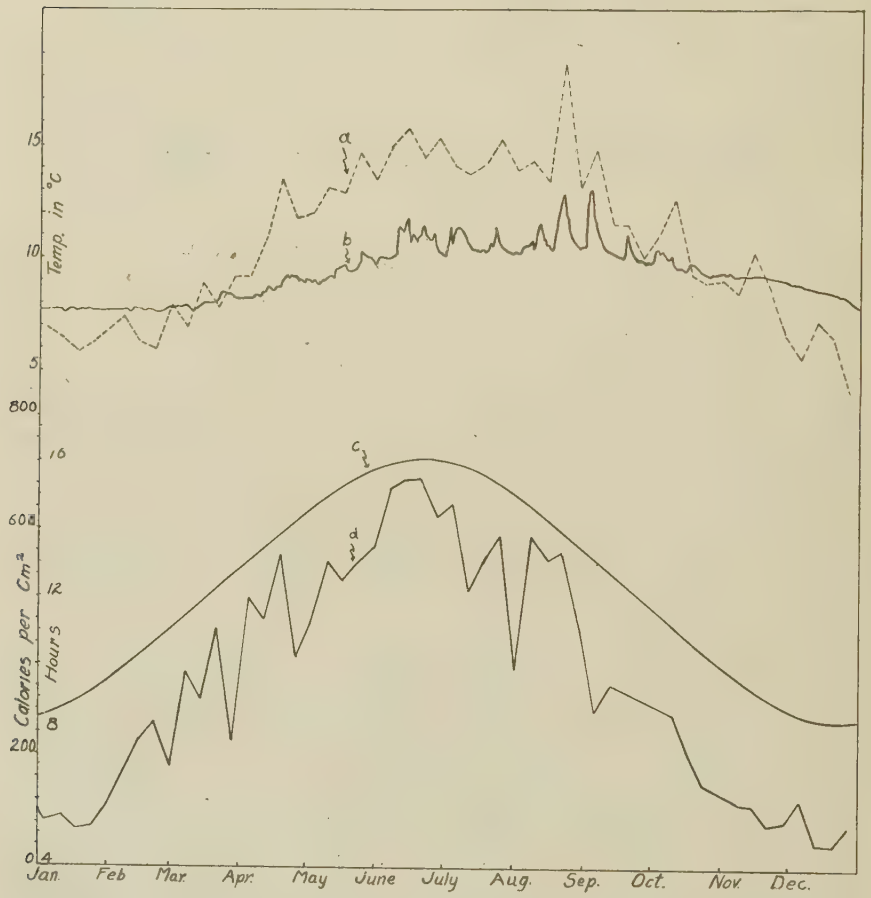

Fig. 1. The curves in this figure show: (a) air temperatures, (b) surface sea water temperatures, (c) time elapsed between sunrise and sunset and (d) total radiation, direct plus diffuse, on a horizontal surface.

Results. Curve "a" was plotted by computing the mean temperature for each week during the year. All temperatures were taken at 8 a. m. An examination of the daily temperatures shows some interesting results. The lowest temperature in 1934 was 1.53° C. on December 30., while the mean for the week December 24—31. was 4.10° C. The

highest temperature was 21.85° C. on August 24. and the mean for the week August 20—26. was 18.48° C. The following table shows the maximum and minimum variations from the weekly averages for each month of the year.

Date	1/16	2/20	3/10	4/22	5/14	6/7	7/24	8/26	9/2	10/14	11/14	12/24
Max.	+61	+52	+43	−35	+35	−31	+34	−20	+46	−41	+31	+100
Date	1/28	2/15	3/18	4/27	5/11	6/20	7/11	8/3	9/12	10/3	11/17	12/2
Min.	+0.8	+3.7	−0.7	−0.9	−0.3	+0.5	+0.4	−0.9	−0.7	−1.7	−0.3	0.0

Table 1. Showing the maximum and minimum deviations, expressed in percentages of the weekly mean, from the weekly mean air temperatures. Plus deviations indicate a temperature greater than the mean and minus deviations indicate one less than the mean.

It will be observed that on some days the air temperatures differed considerably from the weekly mean and that the greatest differences occurred in the winter months.

Curve "b" in Fig. 1 shows the temperature of the sea water at the surface. The data were plotted for each day, thus showing the daily variations. Curve "d" shows the variations in the total solar radiation. It was plotted by taking the weekly averages of the daily total as integrated from the pyrheliometer record. From January 1. to February 4. the pyrheliometer showed no radiation before 7 a. m. and none after 5 p. m. From November 7. to December 31. it showed no radiation before 8 a. m., none after 6 p. m. to December 10. and none after 5 p. m. to December 31.

The early morning radiation reached a maximum value of 4.5 gm. cal. per sq. cm. from 4 a.m to 5 a.m on June 14. The maximum midday radiation was 89.3 gm. cal. per sq. cm. from 11 a. m. to 12 noon on June 15. and the hourly average for the week June 11—17. was 77.3 gm. cal. per sq. cm. between 11 a. m. and 12 noon. The maximum hourly average during the year was 82.6 gm. cal. per sq. cm. between 11 a. m. and 12 noon on the week of June 4—10.

The minimum midday radiation was 1.6 gm. cal. per sq. cm. from 12 noon to 1 p. m. on January 19. and the lowest midday hourly average was 6.5 gm. cal. per sq. cm. from 11 a. m. to 12 noon for the week of December 17—23.

The maximum energy received during any one day was 786.5 gm. cal. per sq. cm. on June 23. The minimum energy received during any one day was 12.3 gm. cal. per sq. cm. on December 11.

Letter to the Editor.

Dear Sir,

I hope investigators will not lose sight of Lee's phenomenon in growth-calculations from scales. In his paper on Norwegian herring in *Rapports* 1934, Mr. Ottestad writes on p. 11, footnote, that Lee "does not take heterogeneity of the material into consideration." Nevertheless, Mr. Ottestad's own selected material, in Table 8 on the same page, appears also to show the phenomenon, although in small degree. His Table 9 shows that this is in t_2 and t_3. The error is small — of little practical importance, but the trend is interesting.

There is, of course, extensive literature on this subject in other fishes, which gives the impression that Lee's phenomenon may be more or less important according to the material. It has been considered as negligible as regards Norwegian herring, but generally speaking it seems rash to regard it as non-existent or due to "heterogeneity of material." Also, the difficulty has produced positive additions to our knowledge, for example in the explanations found by Lea, 1913, Meek, 1916 and Hodgson, 1929, p. 47.

Yours truly,

Michael Graham.

Fisheries Laboratory,
Lowestoft,
18th October 1935.

Essay Review.

Some Recent Publications on the Fauna of Brackish Waters in the Netherlands.

By

H. C. Redeke.

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(2). J. P. Otto und L. F. Kamps. "Die chinesische Wollhandkrabbe in den Niederlanden, besonders in den Provinzen Groningen und Friesland." Ibid. Bd. CX. Leipzig, 1935.
(3). J. P. Otto und D. T. Wielinga. "Hydrobiologische Notizen vom Brackwassergebiet der Provinz Friesland, speziell in der Nähe von Harlingen." Tijdschr. Ned. Dierk. Ver. (3). III. Leiden, 1933.
(4). H. C. Redeke. "Über den jetzigen Stand unserer Kenntnisse der Flora und Fauna des Brackwassers." Verhandl. Intern. Verein. Limnol. Bd. VI. Stuttgart, 1933.
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(6). A. G. Vorstman. "Zur Biologie der Brackwassermuschel *Congeria cochleata* Nyst." Verhandl. Intern. Verein. Limnol. Bd. VI. Stuttgart, 1933.
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(8). A. G. Vorstman. "Biologische Notizen betreffs der sessilen Fauna im Hafen der Stadt Amsterdam." Ibid. Bd. CIX. Leipzig, 1935.

The Netherlands offer as is well known an excellent field for the study of the flora and fauna of brackish waters, as in fact nearly one quarter of the surface lies on the same niveau as or even below sea level. In consequence the soil here is soaked with more or less diluted sea water and almost all "meres", canals, and ditches in the western

and north-western provinces contain oligo- or meso-haline water. It is no wonder many of our hydrobiologists are engaged in problems, both botanical and zoological, bearing on the remarkable life-conditions of this milieu. The chief purpose of this review is to give readers some information as to the scope and the contents of some more recent papers on the ecology and distribution of certain typical lower animals in our brackish waters.

(1). Miss v a n B r e e m e n gives an account of her investigations on the life history of *Balanus improvisus*, the common barnacle of our brackish inland waters. Amsterdam harbour, filled with mesohaline water[1]), offered a good opportunity for this study as the mooring posts and docks in depths from 0 to 3 metres are completely covered by these barnacles, together with the shells of *Congeria cochleata (vide infra)*. Where the individuals have little room for development and appear crowded they are slender and often form colonies. The low, conical form appears only where they grow separately. Adequate collectors were used for the collection of material for the study of growth and duration of life. In agreement with R u n n s t r ö m the author used as a standard measure the carino-rostral diameter of the shell, discarding the very abnormal individuals. As a rule *B. improvisus* lives only one year. Growth and reproduction are correlated with the temperature of the water; they take place from about May to November, at temperatures above 10° C. Under favourable circumstances the growth is very rapid. About three months after fixing on the slides the young barnacles measured 5—8 millimetres and already contained larvae. The same individuals reproduce again next spring and then mostly die off.

2). The second paper deals with the occurrence and distribution of the woolcrab *Eriocheir sinensis* in the Netherlands. This intruder made his first appearance in our country in the summer of 1931, when an invasion of young individuals was observed in the northern provinces, Groningen and Friesland. Some months afterwards a few adult specimens were captured in the estuary of the Rhine and adjacent inland waters. Most probably the young ones came in from the bordering parts of the North-Sea; as to the adults their origin is uncertain. They may have reached Holland from Germany *via* the Rhine or came up through the mouth of the river from the sea after spawning. The small *Eriocheir* reached maturity in the autumn of the next year and a good many egg-bearing females were caught on their way to the spawning places in the salter water off the coast. In the first half of 1933 the number of crabs showed a considerable decrease, but a new and very extensive invasion of young crabs followed in the summer of that year. In August the breadth of their carapaces varied from 5 to 10 mm. in September enormous quantities were caught measuring 8 to 20 mm. The inland waters of Groningen were crowded with crabs so that often a thousend or more were present in a single eel-fuke. In the cold season

[1]) The statement that the water contained 4 milligrammes chlorine per litre (p. 248) is of course a misprint for 4 grammes per litre.

they hibernated in the muddy bottom of the canals. By this second invasion nearly all the waters of Friesland in 1934 have been infected too, and to such an extent that here the density of population was about ten times as great as in 1932. Lastly a new but rather unimportant invasion was observed in December 1934. Nowadays the crabs are a real plague in this part of the Netherlands for which thus far no efficient remedy has been invented. In the remaining parts of the country the catches have been more sporadic, as rarely more than 20—40 crabs were caught at once. Most of these were, however, full-grown individuals. By means of a series of measurements from September 1933 to September 1934 the authors were able to show that these crabs grow in one year from 14 to 52 mm. on the average. It seems therefore very probable that *Eriocheir*, as the authors think, under normal circumstances reaches maturity in the course of three years.

(3). The next paper contains the results of hydrobiological investigations in some Frisian canals, especially in the neighbourhood of Harlingen. These canals are characterized by rather sudden and considerable changes in the salinity of the water, which are caused by the influx of sea-water through the sluices at Harlingen. So for instance at one of the inland stations, situated at a distance of about ten kilometres from the sea, the salinity rose from 1 $^0/_{00}$ in April and May 1929 to 12 $^0/_{00}$ in September of that year. Of course the mesohaline fauna is well represented, especially by Crustacea, of which there were *Balanus improvisus, Iaera marina, Sphaeroma rugicauda, Gammarus zaddachi, G. duebeni, Corophium volutator, Macropsis slabberi,* and *Palaemonetes varians.* Of the mesohaline Polychaetae only *Nereis diversicolor* is mentioned: as the authors payed little attention to the bottom fauna the smaller forms of this group are not listed. In the plankton the true brakish-water species also prevailed, i. e., species which live under optimal conditions in the mesohaline zone. Moreover, some of the common Cl-tolerant freshwater species, chiefly Rotatoria and a few copepods, appeared. The number of marine organisms was relatively small as the majority of them are much more sensible to changes in the milieu than the euryhaline inhabitants of our inland waters.

(4). This is a review of the present state of our knowledge with regard to the biology of the brackish-water biotopes of north-western Europe, based upon the results of the authors own and others observations. The following scheme (Cl-spectrum) is proposed as a convenient subdivision of brackish water in general:

Cl per mille		
$<$ 0.1	fresh water	
0.1 — 1.0	oligohaline	brackish water
1.0 — 5.5	α-mesohaline	brackish water
5.5 — 10.0	β-mesohaline	brackish water
10.0 — 17.0	polyhaline	brackish water
$>$ 17.0	sea water	

The fauna and flora of the oligohaline zone are characterized by the frequency of special Cl-tolerant freshwater species, but this region has also its own typical oligohaline forms. In the polyhaline zone a few euryhaline marine species may be found together with true polyhaline forms. The mesohaline zone, which of course is not sharply separated from the adjoining zones, represents the brackish water *sensu strictiori* and has a well-defined community both of animals and plants of its own. As far as is known at present this brackish-water community is to be found in all mesohaline regions of north-western Europe, and it consists nearly everywhere of the same species. Thus the fauna and flora of the true brackish water is not to be regarded as a mixture of euryhaline marine and freshwater species. In recent years this theory has received considerable support by the discovery of species in various mesohaline regions, which were known as inhabitants of other brackish waters, but in previous surveys escaped notice.

(5). This paper contains, in continuation of a preliminary report (*Journal du Conseil,* IX, 1934), a more detailed account of the distribution of *Acartia tonsa* and *A. bifilosa* in the Netherlands. A complete list of stations is given together with some remarks on the ecology of both species.

(6—7). Both notes deal with the same subject, the biology of *Congeria (= Dreissensia) cochleata.* As is well known this interesting little bivalve was first described by N y s t (1835), who found it in brackish water near Antwerp. Afterwards it has repeatedly been observed in Belgium and the north-western part of France. In 1895 is was collected by M a i t l a n d in the River Amstel near Amsterdam. Later investigations showed its presence in nearly all our more or less brackish inland waters, where it replaces the common freshwater species *Dreissensia polymorpha.* In fact *Congeria* is in certain localities one of the very conspicuous elements of the fauna, forming clusters on submerged wood, stones, and shells and occurring as a rule in the company of *Balanus improvisus (vide supra).* Although it may be found in oligohaline water, it thrives best in the mesohaline zone and therefore occurs abundantly in Amsterdam harbour. Miss V o r s t m a n's investigations are mostly based on material collected in this harbour. Larvae made their appearance from July until October and were collected on submerged slides. The smallest of these larvae measured 0.27 mm. in length. They go on growing until they have reached, about the end of November, an average length of 4 mm. and then stop. In winter time there is no visible growth, but in May of the next year they start again and reach by the end of October a size of about 2 cm. Larger individuals, up to 2.5 cm. were rarely observed. In November and December this generation dies out; so *Congeria* never reaches an age of more than one year and a few months. In the second year a well-defined "year-ring" is always visible on the shell.

(8). The last paper deals with various other animals of Amsterdam harbour, *Cordylophora caspia, Embletonia pallida, Balanus improvisus, Victorella pavida, Polydora redekei,* and contains besides some additional

information on *Congeria*. All these organisms belong to a typical biocoenose which may be taken as representative for such mesohaline habitats which offer still other profitable conditions of existence, as: favourable temperatures, suitable substrata, and an abundancy of food. The occurrence of *Polydora* is of special interest, as it is one of the commonest Polychaetae in our brackish waters, living in muddy bottoms and as a rule accompanied by such species as *Alcmaria romijni*, *Streblospio dekhuyzeni*, and the much rarer *Manayunkia aestuarina*. *Alcmaria romijni* is a little ampharetide, described by H o r s t in the year 1919 from material collected in the Alkmaarder Meer near Akersloot. It may be mentioned here that the very same species was lately secured at different localities in the nowadays brackish water of the Ringkøbing Fiord in Denmark.

Reviews.

A. Hagmeier. "Aufgaben und Bedeutung der Preussischen Biologischen Anstalt auf Helgoland." Der Biologe. III. Jahrg., H. 7. München, 1934.

The importance of the German Biological Station at Helgoland requires no emphasis to marine biologists, yet mention should be made of an instructive illustrated account of this laboratory by its Director, Professor A. Hagmeier, and his colleagues. The laboratory, first established in 1892 under the directorship of Friedrich Heincke, was considerably enlarged during the term of office of his late lamented successor, Professor Wilhelm Mielck. It now stands as a building well equipped for the needs of research workers in the many branches of the study of life in the sea, but the necessary funds are unfortunately still lacking for the final completion of part of the new building.

The Helgoland station carries out to the full the functions of a modern marine biological laboratory. Apart from the work of the permanent staff who are occupied in the continuous observations of the marine biologist, the laboratory serves as a training ground for students and affords accomodation for visiting research-workers.

Besides the general description of the laboratory, the above publication gives short accounts of the various branches of work which cover the ecology of the bottom fauna and plankton, and the study of sea-weeds, and which in their applied aspects range from fishery research to the problems of land formation in the shallow flats. It includes also an account of the Bird Observatory which has been long established and was taken over by the Biological Station.

To those who have not had the opportunity of visiting this famous laboratory the description can be recommended, but to most the value of its work can best be realized by bringing to mind the work of Heincke, Hartlaub, and Mielck, not to mention that of other well-known workers still living.

F. S. R.

J. P. Jacobsen. "Temperaturmessung mit elektrischem Widerstandsthermometer auf der Kattegatsexpedition im August 1931." Medd. Komm. Danmarks Fisk.- og Havunders. Ser. Hydrogr., Bd. III, Nr. 1. København, 1935.

This memoir is based on part of the work of the international expedition to the south Kattegat in August 1931. An electrical resistance thermometer recorded on board the German ship "Hunte" and the instrument itself has been described by G. Böhnecke (Annalen der Hydrogr., 61, 122—124).

An electrical resistance thermometer, of different design, also recorded on board the Danish ship "Japetus Steenstrup" and this instrument is described in detail in the first part of the memoir under review.

The conductor whose resistance measures the temperature is a lacquered nickel wire of diameter 0.15 mm., and the outer cover of the protecting case is a thick brass tube. The resistance of the nickel wire is about 166 ohms and that of the cable about 1 ohm. In calibrating the thermometer formulae were found —

1. for the temperature of the nickel wire in terms of its resistance as measured by the throw of the galvanometer needle with a known E. M. F. in the Wheatstone bridge.
2. for the resistance of the nickel wire in terms of a comparison resistance, to allow for changes in the E. M. F.
3. for the time-rate at which the temperature of the nickel wire approaches that of the sea water surrounding the brass case.

The degree of accuracy in the readings is estimated to be about 0.1° C.

A pressure-gauge, recording on board, was attached to the thermometer so as to check its depth.

The thermometer on the "Hunte" was in continuous operation at a depth of 22.5 m. for nearly 7 days and was read sometimes at intervals of two minutes and sometimes at intervals of four minutes. The thermometer on the "Japetus Steenstrup" was in operation at a depth of 26 metres for over two days and was read at intervals of one minute. The results were compared with the serial readings which were made from the two ships, and such differences as occur can be explained by uncertainties in the depths of the water-bottles. Tables are given of the quarter-hourly means of temperatures.

Using the vertical gradients revealed by the serial readings, the depths of the 11.7° isotherm at the position of the "Hunte" and of the 8.0° isotherm at the position of the "Japetus Steenstrup" are calculated, these two temperatures being approximately equal to the means of the two series. The depths of the two isotherms form the basis of the hydrographic study of the results. Vertical oscillations of periods

12.42, 10.33, 14,37, 4.50

hours are isolated, and are found to have amplitudes ranging from 7.8 to 37 cm. The first of these periods is that of the M_2 tidal oscillation, the third is the half "pendulum-day" corresponding to the latitude, which forms the period of the "inertia-currents", the fourth is the period of the transverse seiche across the Kattegat previously revealed by Jacobsen and la Cour, but the origin of the second is still obscure.

From the small amount of material available it cannot be decided how far the oscillations in the depths of the isotherms are due to vertical oscillations of water and how far they are due to horizontal oscillations with inclined isotherms.

The author concludes by expressing his opinion that the electrical method of registration offers great promise for the future, especially for observations from lightships and regular steamers.

J. P.

H. Mosby. "The Waters of the Atlantic Antarctic Ocean." Norske Vid.-Akad. i Oslo. Sci. Res. Norwegian Antarctic Exped. 1927—1928, No. 11. Oslo, 1934.

The report is principally a description of the waters of the Atlantic Ocean and the western part of the Indian Ocean south of 55° S. The data used are the observations made during three cruises of the "Norvegia" in 1927—1931, and the earlier observations of the "Deutschland", "William Scoresby", "Meteor", and "Vikingen". With the help of a complete series of charts showing the distribution of temperature, salinity, and density; charts giving the topography of several isobaric surfaces relative to the 1000 and 2000 decibar surfaces; and three longitudinal sections, the author determines the properties, origins, and movements of the surface and deep waters.

He describes the Antarctic surface layer as made up of two strata, a surface stratum whose properties vary considerably from winter to summer, and a lower stratum in which there is only a relatively small variation. The summer surface water is winter water diluted with fresh water, and the winter water is renewed from the surface water and the less degenerated water of the lower stratum by the cooling and increase of salinity which takes place when ice is being formed in winter.

The author's work confirms the existence of a cyclonic movement extending across the whole of the southern part of the Atlantic Ocean with its axis in a west-south-west to east-north-east direction, and it also points to the existence of a northward movement in the surface layer which is superimposed on the cyclonic movement. The author does not, however, seem to make sufficient allowance for the northward current when discussing the origin of the surface and subsurface waters; if the Antarctic water flows towards the north it must in the beginning have its origin in the only southward movement — the deep current — and in fresh water from melting ice and snow and precipitation. The author plainly regards the transfer of water from the deep layer to the Antarctic layer as small, but he does not seem to give the question sufficient consideration. The mixing of the surface and deep waters in winter is likely to play a considerable part in the formation of the winter water.

The deep water has a cyclonic movement similar to that of the Antarctic water, and the "Norvegia" observations are a valuable contribution to the data available from the westward movement of warm deep water along the coast of the Antarctic continent. Some evidence given by the "Norvegia" Sts. 15 (1930), 52 (1931), and the "Meteor" St. 130, that the current divides into two branches in about 65° S., 5° E. is regarded by Mosby as a misrepresentation of the actual conditions, brought about by combining data from different years, but it is reasonable to suppose that the current does divide on the Maud Bank, on which the observations at the "Norvegia" St. 52 were made; the data from this station do not seem to have been fully available when the report was written since the author was not aware of the shallow sounding.

The author gives a comprehensive review of the theories as to the origin of the Antarctic bottom current, and finds that it is formed by the mixing of roughly equal masses of shelf water and deep water in the south-western part of the Weddell Sea, a view which is in accordance with that of Brennecke put forward in 1921.

In addition to the account of the waters in the open sea, the report describes the hydrography of Cumberland Bay, and Drygalski Fjord, South

Georgia, and also of the coastal waters of Bouvet Island. The author and his colleagues in the "Norvegia" clearly seized every opportunity of doing useful work, and a short review cannot do justice to the results; the report needs, and is worth, a close study.

G. E. R. D.

P. M. van Riel. "Soundings and Bathymetric Charts: The Bottom Configuration in Relation to the Flow of the Bottom Water." *Snellius*-Exped. Vol. II, Pt. 2, Oceanogr. results. Utrecht, 1934.

Dass die niederländisch-ostindischen Tiefen besonders in ihren östlichen nach dem Stillen Ozean hin gelegenen Teilen die weitaus reichgestaltetsten in allen 3 Weltmeeren sind, das lehrt von neuem und eindrucksvoll die von zahlreichen und vorzüglichen Tiefenkarten begleitete Veröffentlichung van Riels. Es ist ein wissenschaftlicher und — dank der technischen Ausführung durch den Topographischen Dienst — ein ästhetischer Genuss, die Karten zu studieren, die für den Ozeanographen, aber auch für den Biologen u. s. w. bedeutsam sind. Eine in dem relativ sehr grossen Masstab 1: 2,500,000 gehaltene Karte (Doppelblatt) gibt den Einblick in die gewaltige Vermehrung unserer Kenntnis durch die 32,000 Echolotungen des "W. Snellius" östlich von Java-Borneo; eine Übersichtskarte in 1: 5,000,000 umfasst auch die Gewässer westlich von Sumatra und südlich von Java und reicht ebenfalls bis hinaus zum Stillen Ozean, bringt also den gesamten Sunda-Archipel mit vielen neuen Einzelheiten. Dazu kommen 16 Nebenkarten hauptsächlich zur Veranschaulichung des untermeerischen Reliefs in den zahlreichen Verbindungsstrassen der einzelnen Becken und Mulden. Die Isobathenzeichnung beruht nicht einfach auf den Lotzahlen, sondern — für die Schwellentiefen — auf sorgsamer Berücksichtigung der auf den beiden Seiten der Schwelle gefundenen Wassereigenschaften, in erster Linie also der *potentiellen* Tiefentemperaturen. Dies Verfahren trägt hier, wie Text und Textfiguren erkennen lassen, reiche Früchte. Der Verfasser gibt für 27 mehr oder weniger selbständige Meeresteile die Schwellen- oder Satteltiefe nebst den zugehörigen Werten von S $^0/_{00}$ und t° in einer Liste (S. 56), die — nebenbei bemerkt — benutzt werden kann, um in der vor kurzem erschienenen "Geographie des Indischen und Stillen Ozeans" (S. 99) des Referenten einige Einzelheiten zu korrigieren. In ähnlicher Weise konnte van Riel nicht mehr den vollen Gebrauch von den Echolotungen der "Dana" machen; doch ist S. 18 und in einem Appendix noch eine wichtige Grossform unterseeischer Bodengestaltung, die frühere Karten nicht haben, sehr wahrscheinlich gemacht, nämlich eine *untermeerische Verbindung von Neu-Guinea über die Palau-Inseln und Marianen-Bonin-Inseln mit Japan* (Tiefen $<$ 3660 m.).

Nicht bloss ozeanographisch, sondern auch biologisch besonders wertvoll ist Taf. IV.; in ihr ist, unter farbiger Heraushebung der Becken und Tröge, die Richtung des Bodenstroms durch Pfeile angegeben. Hiernach stehen fast sämtliche Sunda-Binnenmeere in Zirkulation mit dem Stillen Ozean, sogar die Sawoe-See im Süden; nur die Timor-See und das kleine vor Süd-Neuguinea gelegene Aroe-Becken beziehen ihr Bodenwasser vom Indischen. Der Berichterstatter würde vorgeschlagen haben, schon jetzt diese eindrucksvoll und wichtige Karte hier dieser Anzeige beizufügen, wenn nicht van Riel in Aussicht gestellt hätte, in einer weiteren Sonderarbeit den Gegenstand ausführlich zu behandeln.

Aber auf einen Punkt sei noch hingewiesen, weil er für jeden mit dem

Meere beschäftigten Forscher grundsätzlich wichtig ist, auf die Darstellung der Bodengestalt durch Profile. Man wird es van Riel als ein Verdienst anzurechnen haben, dass er seiner Arbeit von den meisten Becken *naturgetreue* Profile beigegeben hat — unbeschadet übertiefter Bilder für die t°-Verteilung. Im Anschluss an die "Meteor"-Lotungen sind besonders von deutscher Seite, zuletzt z. B. von Th. Stocks und G. Wüst ("Meteor" Werk, Band III, 1. Teil, S. 9) Profile in 1:100 und 1:200 Übertiefung zur Vermittelung rein topographischer Anschauung mehrfach veröffentlicht worden, die selbst bei Wissenschaftlern eine ganz bedenkliche Vorstellung erwecken müssen, wenn man dabei auch noch so oft sich die Übertiefung in das Bewusstsein ruft. Mit Recht erklärt van Riel, dass übertiefte Profile, soweit sie topographischen Zwecken dienen sollen, "*give a total erroneous impression of the shape of the bottom line*". Welch' phantastische Profile hätte van Riel aus seinem Arbeitsgebiet dem Leser vorsetzen können! Er ist dieser Versuchung nicht erlegen. Man betrachtet mit grossem Nutzen seine naturgetreuen Schnitte durch die Banda-See, Celebes-See, die Philippinen-Rinne oder den Mindanao-Trog mit der grössten Weltmeertiefe) u. s. f. Für uns Menschen bedeuten Niveauunterschiede von mehreren Hundert Metern etwas Beträchtliches; auf die gewaltigen horizontalen Entfernungen am Boden der Tiefsee gerechnet, bleiben sie in den weitaus meisten Fällen tatsächlich Kleinigkeiten des natürlichen Reliefs.

G. Schott.

R. Witting. "Zur Bestimmung der Mischung im Meere." Soc. Sci. Fennica, Comment. Phys.-Math., Vol. VII, Part 2. Helsingfors, 1933.

The author has carried out experiments in the Gulf of Finland on turbulent mixing in the sea. Aft of the anchored ship "Nautilus" a mixture of sea water and a freshwater solution of the magenta aniline dye fuchsine, in fixed proportions, was led through an L-shaped tube into the sea. Samples were taken from the sea, and their colour strength determined by colorimetric comparison with prepared solutions (of strengths 1:5000. 2^{n-1}; $n = 1, 2, \ldots 11, 12$).

In his theory the author simply assumes that in the steady state the concentration, u, satisfies an equation

$$s\frac{\partial u}{\partial x} = a^2\frac{\partial^2 u}{\partial x^2} + b^2\frac{\partial^2 u}{\partial y^2} + c^2\frac{\partial^2 u}{\partial z^2} \qquad (1)$$

where s is the stream velocity, a, b, c are assumed to be constant, and x, y, z are rectangular coordinates, x being in the direction of the stream and z vertically downwards. He obtains the approximate formulae

$$a \quad \frac{R}{2}\sqrt{\frac{sK}{xu(x,o,o)}}, \quad b \quad \frac{y}{2}\sqrt{\frac{Ms}{x\log\frac{u(x,o,o)}{u(x,y,o)}}}, \quad c \quad \frac{z}{2}\sqrt{\frac{Ms}{x\log\frac{u(x,o,o)}{u(x,o,z)}}}$$

where R is the radius of the entry, supposed circular, K the concentration at entry, M is $\log_{10} e$ ($= 0.4343$), and the origin is at the centre of the entry. In the first of these formulae, it is assumed that a, b and c are equal at the entry; but if this assumption is not quite true, it is not likely to have any marked effect on the values of a.

In tabulating his results, the author gives the direction and speed of

the wind (and its strength on the Beaufort scale); the direction and speed of the stream, the temperature, the salinity and the density at various depths; and the breadth and depth at which the colour becomes indistinguishable, and the calculated values of *a*, *b* and *c*, at various distances from the entry. He also gives a "corrected" value of *a*, calculated from an "effective" radius $E = R \sqrt{10.25/s}$, 10.25 cm./sec. being the speed at which the solution leaves the tube.

The values of *a* are, on the whole, not too widely scattered, being about 3—3.5 cm./sec.$^{1/2}$. There are "corrected" values recorded as high as 5 and as low as 1.5, but the extreme ones are probably abnormal and erroneous. On the other hand, the values of *b* show a large and progressive rise from about 3 or 4 cm./sec.$^{1/2}$ at about 15 metres to about 25 cm./sec.$^{1/2}$ at about 200 metres from the entry; whilst *c* decreases from about 3 to 1.7. There is a small increase in the values as the wind speed increases from 2 to 4.2 m./sec., but no satisfactory evidence for any increase as the speed of the stream increases from 3 cm./sec. to 23 cm./sec.

The rapid increase in *b* was due to causes other than the usual turbulent mixing. The author mentions the motion of the ship, and the repeated gliding of a boat backwards and forwards over the coloured band in the process of taking samples. But the effect was not due to an increase in the vigour of mixing. The author reports that the distribution of the concentration over a cross-section was not symmetrical; there were several maxima, separated from each other by bands of less highly coloured, or even of entirely uncoloured water, so that the increase in the values of *b* is due to a different phenomenon from that of turbulent mixing by small eddies. The author reasons that the most trustworthy values are the values of *a* near the entry. The decrease in the values of *c* he ascribes not only to the variation of velocity with depth, but also to an actual decrease in the vigour of the turbulent mixing with depth.

It will be noticed that the author's theory is deficient in several respects. By basing his investigations on equation (1) he has taken no account of the latest theories of turbulent mixing; the assumption of the constancy of *a*, *b*, and *c* is not, in fact, justified *a posteriori*, and no account is taken of the variability with depth of the stream-velocity or of the density. In spite of these deficiencies, and of the difficulties of the observations, the author's records give useful material for a knowledge of the order of magnitude of the so-called "Austauschkoeffizient" in the sea.

S. G.

S. M. Marshall, A. G. Nicholls and A. P. Orr. "On the Biology of *Calanus finmarchicus*. Part VI. Oxygen Consumption in Relation to Environmental Conditions." Journ. Mar. Biol. Assoc. N.S., Vol. XX, No. 1. Plymouth, 1935.

The experiments considered here were designed primarily to find the food requirements of *Calanus finmarchicus*, and so eventually to link up the knowledge of its life history with that of the periodicity of phytoplankton in the Clyde sea area.

It is immediately apparent that respiration is affected by a variety of factors and those considered in the present account include: duration of experiment, temperature, pH, salinity, oxygen content, sunlight and variations in light intensity: male, female, and Stage V *Calanus* were investigated.

Oxygen consumption in the first few hours of an experiment may be considerably greater than later and it would appear that the shorter the interval of time between capture and the start of an experiment, the more rapid will be the initial fall in oxygen consumption. The authors have satisfied themselves that neither shortage of food nor exposure to variations in light intensity afford the explanation. That it is the result of heightened metabolism due to disturbance — collection, introduction into test vessel etc:, — or to increased movement caused by impact with sides or with each other, would seem to be negatived by the fact that Stage V *Calanus* shew no definite fall.

Observations on variations of Oxygen consumption with temperature enabled the upper lethal temperature to be determined. For specimens caught in summer (July) this was about 2°C. higher than for those caught in April.

Variations in pH were without influence on Oxygen consumption.

Oxygen content could be raised to an abnormally high level without effect; lowering the Oxygen content caused a fall in consumption and finally death.

Salinity could be reduced to approximately 50 % sea water without effect, but at lower levels oxygen consumption fell and death ensued.

The effects of light on respiration are of considerable interest. Laboratory experiments shewed that increased light raised the consumption considerably, albeit with no increase in activity.

When *Calanus* were suspended at different depths in the open sea it appeared that below 5 metres light was without effect, the consumption here lying, for males, between 0.23 and 0.39 (corresponding value for specimens kept in dark bottles being 0.28).

In the experiment quoted on p. 15 — effect of continued exposure to sunlight on respiration — it seems that exposure for 6 hours is without influence on consumption. These data are interesting in that the value for specimens kept in the dark is unusally high. The authors suggest that this may be due to the fact that the *Calanus* used had been taken in surface tow-nettings by day. The lower value which was obtained in the dark after the specimens had been exposed for 6 hours suggests to the authors that the *Calanus* had been damaged by so long an exposure. Both the points raised are of considerable interest and it is unfortunate that in this case the time interval between capture and experiment is not stated.

The authors conclude with sections on the bearing of these observations on the relation of *Calanus* to the environment and to its food requirements.

A. C. G.

E. R. Gunther. "Observations on the fatty constituents of marine plankton. I. Biology of the plankton."

G. Collin, J. C. Drummond, J. P. Hilditch and **E. R. Gunther.** "Observations on the fatty constituents of marine plankton. II. General character of the plankton oils."

J. C. Drummond and **E. R. Gunther.** "Observations on the fatty constituents of marine plankton. III. The Vitamin A and D content of oils derived from plankton." Journ. Exper. Biol. Vol. XI, No. 2. London, 1934.

The main object of this trilogy was to shed light on the origin of vitamins A and D in marine fishes by an investigation into their possible presence in the coastal plankton of British seas.

The plankton was taken from the surface of the sea near Port Erin, by tow-nets having 70 meshes to the linear inch. Five samples of phytoplankton and eight of zooplankton were made during the periods 22nd—25th May and 16th—20th July 1928 respectively. All the work was carried out during daylight. The samples were settled and concentrated, portions being preserved in absolute alcohol and others salted for the chemical work. Other samples were reserved for biological counts.

Ninety per cent. of the phytoplankton consisted of *Chaetoceras* spps. and *Lauderia borealis;* there was also present zooplankton in the approximate numerical relation of 1:1,000,000,000. The zooplankton consisted mainly of copepods. In connexion with the evaluation of this plankton interesting and extremely useful graphic approximations have been made relating size to volume. Numerous careful measurements have been made and the organisms of different sizes have been translated into numbers per cubic centimetre by the use of packing and displacement methods. The graph for the length-volume ratio is linear for the chaetognaths, but in a composite graph which includes *Coscinodiscus* a curve is produced. It is thought possible that this curve is due to excessive volume estimates for the smaller copepods and *Coscinodiscus,* otherwise the tendency for the relation to be linear would be apparent. The translation of numbers into volume brings out the pre-eminent importance of stage V and adult *Calanus finmarchicus.*

The oil yield of the phytoplankton was approximately 6.89 % of the dry weight, while that of the zooplankton varied between 15.05 % and 19.3 %.

The highest values for the zooplankton oils came from those samples which were richest in *Calanus.* The zooplankton oils were generally similar to clupeoid and gadoid liver oils. The resemblance was particularly marked by the high proportions of C_{20} — C_{22} highly unsaturated acids.

The non-saponifiable part of the zooplankton oil amounted to about 28 % and contained cholesterol, a hydrocarbon similar to or identical with squalene, cetyl, ecosyl and possibly batyl alcohols as well as traces of ergasterol inferred from the vitamin D tests.

Vitamin A, as such, was not found in either kind of plankton oil, but a growth-promoting effect was found to be present. This was thought to be connected with lipochrome pigment related to carotin and was of greater potence in the phytoplankton. Evidence of the presence of vitamin D was obtainable only from the zooplankton oil. It is suggested that the presence of this small amount may have been due to the irradiation of the zooplankton whilst in the surface waters.

R. S. W.

R. Herpin. "Le peuplement d'une place vide dans la nature (la nouvelle plage de Cherbourg)". Ann. Sci. Nat., 10e. Série, Zoolog. Vol. XVIII. Paris, 1935.

The study of the repopulation of sterilized areas gives a valuable insight into the growth and interrelation of the colonizing species under conditions simplified by the reduction of such factors as competition for space. Such a study has been possible on a large scale on such land areas as Krakatoa, but in the sea it has so far been limited to the study of the colonization of new structures such as piers, and the recolonization of artificially cleared small areas of rock or wood.

The construction of a new sandy beach at Cherbourg offered a unique opportunity for studying the colonization of sand under similar conditions. The beach, about 200—300 metres in depth and 500 metres long, was covered to a depth of half to one metre with sand dredged near by from a depth of four to nine metres. When completed in June 1932 the sandy beach was practically barren of life. The chief exception was the presence of a few patches of relict fauna which had survived from the earlier beach, comprising *Audouinia tentaculata, Arenicola marina, Nephthys caeca,* and the anemone *Cylista viduata.*

Subsequent colonization was of two kinds — the invasion of adult forms, which was the first phase, and later the settlement and growth of free-swimming larvae. The adults were motile forms such as *Ophiodromus flexuosus* and various spionids. Along with these came diatoms on the sand surface, and algal spores on the stones — *Callithamnion corymbosum* and *Pilaiella littoralis* first, followed by *Polisiphonia* spp, *Rhodymenia, Porphyra,* and *Fucus.* The second phase (spring 1933 to spring 1934) contained animals which utilized the food and shelter provided by the earlier colonizers: on the stones *Ascidia mentula, Pomatoceros, Balanus,* and a very rich polychaete fauna sheltering among these, and in the sand young *Arenicola marina, Nephthys, Audouinia,* spionids, capitellids etc.

This paper gives a detailed account of the pre-existing fauna, and preliminary observations on the process of recolonization. The chief generalization emerging at present is the necessity of a plant fauna in the sand (mostly diatoms) before the animal fauna can establish itself in any quantity. The future development of the area will render these early stages even more interesting. It is to be hoped that along with this, the opportunity will be taken of giving details of the rate of growth of the colonizing polychaetes.

H. B. M.

J. A. Kitching. "An introduction to the ecology of the intertidal rock surfaces on the coast of Argyll." Trans. Roy. Soc. Edinburgh. Vol. LVIII, Pt. II, No. 15, pp. 351—374. Edinburgh, 1935.

Conditions in the intertidal region of the shore are rendered very complex by the numerous and widely varying environmental factors involved. In this paper Kitching describes the distribution of some of the important intertidal animals and algae in an area where conditions are to some extent simplified. Every stage from high wave-exposure to complete shelter is available within a short distance; tidal ranges vary from six to fifteen feet at spring tides; and most important of all, shore surfaces dropping comparatively uniformly and at an even slope into deep water are plentiful. This account is confined to primary forms, deriving their food supply directly from the water, i. e., as plankton or dissolved salts. Secondary forms such as *Patella* and *Purpura,* which depend for their food on other littoral species, are not considered.

Wave-exposure plays an important part in determining distribution. The splash-zone is raised by wave action, so that forms like *Pelvetia canaliculata* and *Chthamalus stellatus* can reach a higher level than in a sheltered place. On the other hand fragile forms like *Antedon rosacea* and *Ascidea virginea* may ascend into the intertidal zone in places where this is sufficiently sheltered. The angle of slope of the surface is another factor with clearly

defined limits for certain species. Here, however, several other factors seem to be involved, such as the adequacy of the resulting illumination (in certain algae), or the degree of protection from too great illumination (some sponges). Tidal level also has a very marked controlling effect on distribution, involving as it does such factors as period of immersion, period of insolation, etc., and these in turn involving further factors such as the period available for feeding, the diurnal range of temperature, etc. Here, therefore, it is difficult to separate the individual factors directly concerned.

A detailed account is given of the distribution of the various species concerned. Where there is an obvious relation to environmental factors this is discussed. In addition a table is given of the observed values of pH, oxygen concentration, and temperature at a representative series of stations. The value of this paper lies not only in its new observations on distribution, but also in its attempt to give an accurate measure of some of the environmental conditions, and thus render possible a comparison with other localities.

H. B. M.

W. Templeman. "Lobster tagging in the Gulf of St. Lawrence." Journ. Biol. Board Canada. Vol. I, No. 4. Toronto, 1935.

The experiments in marking lobsters agree in respect of results which indicate a relative sedentary behaviour. Few have been found to have migrated any notable distance from the place of marking. In this case the result is not surprising, for the lobsters were captured and liberated at the lonely Magdalen Islands in the Gulf of St. Lawrence, a region with the lobster fishing grounds near the islands and deep water all round. The recaptures were made therefore in the region of marking and on either side. As the marking took place at the end of the summer of one season and the recaptures early in the following season, all that can be gathered is that in the interval the lobsters had visited deeper water and returned. Nor did they go round the islands from the eastern to the western side. Not one was reported from any region but the islands. An earlier experiment on the coast of the Northumberland Strait gave similar results. The only indication of some degree of sex difference was that the females to some extent migrated, or rather returned, to a region more distant than the males.

The lobsters marked were large and mature and had recently cast. The method of marking by a label fastened by piercing the telson, is open to criticism, for it is evident that when casting took place the freeing of the cuticle would be very difficult, indeed impossible. The marking on the Northumberland coast was done simply by threading the metal label on a piece of copper wire and twisting the latter loosely, around the base of the large claw (chela) and this method proved satisfactory, and the method if adopted would avoid the risk of converting the subject of experiment into a victim.

A. M.

T. H. Järvi. "Die Seefischerei von Finnland." Handb. d. Seefisch. Nordeuropas, Bd. VIII, H. 4. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Nägele) G. m. b. H., Stuttgart, 1934.

A new volume in the series edited by Lübbert and Ehrenbaum, on the fisheries of Northern Europe, deals with the fishery of Finland.

The work is well arranged, full of useful information and provided with excellent reproductions, to a great extent from the author's own photographs.

The Finnish sea fishery is rather remarkable and gets its principal character from the circumstance that small herring (strömming) is the only purely marine fish species occurring and caught everywhere along the coast. Other sea fish, for instance, sprat, cod, and flounder, are taken only on the south-western coast of the country, and are of very little importance compared with the small herring. But a great many freshwater fish, such as pike, ide, perch, bream, etc., together with the migratory salmon, sea trout, and powan contribute to the sea fauna in the widespread Finnish archipelago. The salt-water fishery of Finland ought to be looked upon as a coastal fishery. There is no real high-sea fishery, unless the fishing of small herring during the winter on the ice out at sea in the Gulf of Finland could be claimed as such. This characteristic does not apply to the fishing from Petsamo at the Barents Sea, which is insignificant in comparison with the Baltic fishery.

The peculiarity of the Finnish fishery has its ground in the special conditions of nature which characterize the district. The author has discussed these very closely in the general introduction. This section is followed by an account of the laws of the fishery, data concerning the fishing population, a summary of the return of the fishery, its general character, and the various fishing districts with the occurrence within them of the different fisheries. Then the author describes the different fisheries detail, in following the principle first to relate the biological conditions in Finnish or neighbouring waters, as far as they are known, which concern the fish species in question, and then to describe the different methods of catching.

By far the most important fishery is the one for small herring. It yields not less than 80 % of the total catch of the sea fishery and a little more than half the total value. Of special interest is the winter fishery on the ice out at sea in the eastern parts of the Gulf of Finland and in the archipelago of Åbo. The description of the fishing of the other, proper salt-water fish, sprat, cod, flounder, and turbot, shows that only the sprat fishery is of importance. However, it does not amount to more than 1 % of the total catch and value of the sea fishery. Of the more important sections the description of the pike fishery may be mentioned, which is very large, especially in value, and also the account of the important powan fishery which takes fourth place in value of catch. Considerable space is spent on the salmon fishery, but then, next to the small herring fishery, it is the most important in Finland, and the value of the catch comes to 12 % of the total value. Moreover, it has a very interesting and highly developed technique. After the account of the sea trout, eel, and lamprey fisheries, there follows a description of the sealing and of different types of fishing boats, and, finally, of the fishing at Petsamo and the newly begun herring fishery at Iceland.

Some data on the export of fish from Finland are given. These exports went principally to Russia before the Great War, and entirely during it. After the Great War the largest quantities have been exported to Sweden and Esthonia, though the export has declined considerably compared with the time before the war.

There are many interesting aspects of the Finnish fishery to which attention is drawn by Professor J ä r v i's work, and for those who wish to study its details this work will be an important and valuable source of information.

Molander.

N. Peters. "Angeln". Handb. d. Seefisch. Nordeuropas. Bd. IV, H. 4. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Nägele) G. m. b. H., Stuttgart, 1935.

This pamphlet of 48 pages costs twenty-two shillings. So much has the price of German books increased. This part of the fourth volume of the Handbook of the Sea Fisheries of Northern Europe contains an account of line fishing by Dr. Peters, of the Zoological Museum, Hamburg. It is a thoroughly sound, comprehensive, and up-to-date description of what is still an important branch of coastal and deep-sea fishing. After a short introduction the author gives a historical account of the various types of hooks in use from the earliest times. This section of the work is well illustrated and it is easy to follow the development of line fishing and the adaptation of different kinds of hooks to different purposes. A very interesting description is given of the tracing of the migrations of fish by means of hooks which have been left in their jaws when they have managed to free themselves. In particular there are interesting maps showing the migrations of the salmon in winter in the southern part of the Baltic and of the tunny into the Mediterranean. An extension of this method of research is plainly indicated by giving the line fishermen hooks with distinguishing marks.

The different methods of line fishing practised by inshore and deep-sea fishermen are next described; with special notes on fishing for cod, the Greenland shark, eels, and cuttlefish (these last being required for bait). A separate section deals with whiffing (Schleppangeln) for mackerel. Here again, as in fact throughout the whole work, the illustrations are well selected and serve excellently to elucidate the text.

Long-lining is then dealt with, and the Dutch line fishing is dealt with in an exhaustive manner, in great detail with reproductions of excellent photographs. The Norwegian line fishery for cod at the Lofoten islands, as well as for coalfish; and the fishery for the herring-shark *(Isurus cornubicus)* are also described. The British long-line fishery next receives attention, including the halibut fishery off the coast of Greenland initiated in 1926.

The last chapter is devoted to the bait question. Finally there is a short but satisfactory bibliography. The whole work is lucid and concise. It reflects the greatest credit on the author, Dr. Peters, on the editors, Drs. Lübbert and Ehrenbaum, and on the publishers. It maintains the high standard of the *"Handbuch"* and no student of the sea fisheries of Northern Europe can afford to neglect it.

J. T. J.

F. M. Davis. "Mesh Experiments with Trawls 1928—1933." With an Appendix by H. J. Buchanan-Wollaston. Min. Agric. and Fish., Fish. Invest. Ser. II, Vol. XIV, No. 1, 1934. London, 1935.

Welche ungeheure Menge von Arbeit und Mühe in den Untersuchungen steckt, über die hier in knappster Form berichtet wird, kann wohl nur derjenige ermessen, der sich selbst mit der Erprobung der Fangwirkung verschiedener Netzmaschen befasst hat. Alle Fischereibiologen müssen dem Verfasser dankbar sein, dass er diese Arbeit auf sich genommen hat.

Nach der Ablehnung des Planes eines Schongebiets für die Scholle in der Nordsee (1926) wurde die Frage lebhaft erörtert, ob man das Trawl

so umgestalten könnte, dass die Vernichtung untermassiger Fische eingeschränkt würde. Verschiedene Schontrawlmodelle wurden entworfen und erprobt, aber, wie Verf. im Abschnitt IX seiner Arbeit kurz darlegt, nicht bewährt erfunden. Dagegen schien es möglich, durch Verwendung gewöhnlicher aber weitmaschiger Trawls viele untermassige Rundfische zu schonen. Zunächst erhob sich die Frage, ob die Fische durch die Maschen des Steerts schon beim Schleppen, oder, wie vielfach behauptet wurde, erst beim Hieven entkämen. Im zweiten Falle war anzunehmen, dass sie grossenteils nicht mehr lebensfähig sein würden, und dass seine wesentliche Schonung daher auf diese Weise nicht zu erreichen wäre. In Abschnitt II beschreibt der Verf. eine Versuchsanordnung, die es ihm einwandfrei nachzuweisen gestattete, dass die kleinen Fische bereits während des Schleppens entkommen. Die nächste Aufgabe war es, die Selektion von Maschen verschiedener Weite bezüglich verschiedener Fischarten zu bestimmen. Sehr sorgfältige Untersuchungen wurden gemacht über die Abhängigkeit der Maschenweite von dem verwendeten Material, der Konservierung, dem Umfange der beim Stricken benutzten Spule etc. Die Tabelle xvi des Anhangs enthält die näheren Angaben über die Befunde und gibt erwünschte Gelegenheit, die Maschenweite verschiedener Netze einwandfrei zu vergleichen. Für die Feststellung der Selektion der Maschen kommen verschiedene Methoden in Betracht. Da ist einmal das von Russell und Edser eingeführte Hosentrawl (trouser trawl). Verf. findet, dass die Fangmenge in dem beim Einholen achtern befindlichen Steert auch bei gleicher Maschenweite erheblich grösser ist. Diese Fehlerquelle wird ausgeschaltet, wenn man zwischen je zwei Versuchsfängen die beiden Steerte miteinander vertauscht. Unter dieser Bedingung hält Verf. die Methode für geeignet zur vorläufigen Orientierung.

Die zweite Methode, vom Forschungsdampfer auf dem gleichen Fangplatz abwechselnd mit den beiden zu vergleichenden Steerten zu fischen, hat, wie Abschnitt VIII lehrt, nicht den gewünschten Erfolg gehabt. Offenbar änderte sich während der Versuche die Fischbevölkerung des Fangplatzes zu stark (Ref. hat mit dieser Methode im Schollengebiet der Deutschen Bucht bessere Erfahrungen gemacht. Es zeigte sich aber auch hier, dass sehr weitmaschige Netze weniger grosse Fische fingen als das engmaschige Vergleichsnetz. Dies deutet auf einen methodischen Fehler).

Ausgedehnte Versuche, über die in Abschnitt IV und V berichtet wird, wurden mit Decksteertnetzen angestellt. Bei diesem Gerät gibt der Prozentsatz der in den Decksteert gelangten Fische jeder Länge vom Gesamtfang des Geräts ohne weiteres die "Selektions-Ogive". Im Anhang zeigt Buchanan-Wollaston, dass dies der klarste, richtigste und vollständigste Ausdruck für die Selektion der verwendeten Netzmasche ist, und warnt vor der schematischen Angabe des Prozentsatzes der entkommenen und zurückgehaltenen Fische ober- und unterhalb einer bestimmten Länge, da dieser Prozentsatz weitgehend von der Zusammensetzung der befischten Bevölkerung abhängig ist. Davis' Kontrollversuche zeigen leider, dass die Fangwirkung der Steertmaschen durch das darüber angebrachte Decknetz beeinflusst wird. Es werden zuviel kleine Fische im Innensteert zurückgehalten, und der 50 % Punkt der Selektions-Ogive (Scheidewert) liegt zu tief. (Bei den Schollenfängen des Ref. betrug dieser Fehler fast 4 cm.!). Ausserdem werden in dem Steert mit Decknetz zu wenig grosse Fische gefangen, wahrscheinlich weil das Decknetz den "Zug" des Netzes herabsetzt. Der Versuch, eine rechnerische Korrektion anzubringen, befriedigt nicht, und so werden die Ergebnisse der Decknetzfänge nur benutzt, um die Selektionswirkung bezüglich verschiedener Fischarten zu vergleichen.

Ausschlaggebend ist das grosse Experiment, das unter wissenschaftlicher

Kontrolle von der praktischen Fischerei durchgeführt wurde. Zwei Fischdampfer einer Reederei in Shields, Schwesterschiffe, führten gemeinsam 12 Fangreisen aus, wobei das eine mit dem handelsüblichen, das andere mit einem weitmaschigen Netz fischten. Hierin wechselten sich die beiden Schiffe ab, um die "persönlichen" Fehler auszuschalten. An Bord wurden laufend sorgfältige Untersuchungen über die Maschenweite der Netze, die Menge der gefangenen Fische aller Arten und Marktsorten, die Menge der mitgefangenen untermassigen Fische und des Beifangs von Wirbellosen etc. sowie vor allem Messungen der Länge der Schellfische, marktfähiger und untermassiger, vorgenommen. Im Hafen wurden Gewicht und Geldertrag der Anlandungen beider Schiffe ermittelt. Es zeigte sich, dass die mit dem weitmaschigen Netz gemachten Fänge einen etwas höheren Geldertrag lieferten als die mit dem normalen Netz, trotzdem erhebliche Mengen kleiner Schellfische bis zu 30 cm. Länge durch die weiten Maschen entkommen waren, die das normale Netz zurückgehalten hatte und die z. T. auch als marktfähig gelandet waren. Das weitmaschige Netz fing indessen absolut mehr grosse Schellfische, die wegen der geringeren Beifangmenge auch weniger gedrückt waren, und dies genügte, um den der Zahl nach erheblichen Ausfall der kleinen nach Gewicht und Wert auszugleichen. Würden weitmaschige Netze allgemein eingeführt werden, so würde der Vorteil infolge der Schonung untermassiger Rundfische mit der Zeit noch erheblich grösser werden. Der einwandfreie Nachweis, dass die Verwendung weiterer Maschen von vorn herein keinen wirtschaftlichen Nachteil bringt, wird die allgemeine Einführung schonenderer Geräte sehr erleichtern.

Bckm.

R. Kändler. "Rassenkundliche Untersuchungen an Plattfischen. I. Variabilitätsstudien an den Flossenstrahlen- und Wirbelzahlen der Ostseeschollen." Ber. deutsch. Komm. f. Meeresf. N.F., Bd. VII, H. 4. Leipzig, 1935.

This paper deals chiefly with racial differences of plaice populations from different parts of the Baltic, but contains also some information about the plaice of the North Sea. The author divides the Baltic in the usual way into two parts, viz., the Western Baltic, comprising the Bay of Kiel and the Bay of Mecklenburg up to the line Gedser — Darsser Ort, and the "Baltic proper" ("eigentliche Ostsee"), being the remaining part east of that line.

After some preliminary remarks on the validity of "races" and "racial differences" in general the author comes to the conclusion that morphological characters alone are not always sufficient to define a race, but that it is necessary, especially in the case of fish, to take into account also biological data (spawning place and spawning time, distribution of eggs and larvae, etc.). As to the morphological characters he rightly points out, that in racial investigations only such numerical characters should be used as are constant during life.

Kändler confines himself in this study to the numbers of the vertebrae and of the rays of the anal fin. He gives a detailed account of the methods followed and lays much stress upon the staining of these bony structures with alizarine, by which elements containing calcium are beautifully coloured.

An important part of his paper is devoted to a very useful description

of the various anomalies occurring in the structure of fin rays and especially of the vertebrae. Anyone who is familiar with this sort of investigations knows how troublesome it is in many cases, to fix the exact number of those parts, if more or less evident fusions or divisions have taken place. If we have to do with median fins the case is rather simple, as the true number always can be found by counting the radials (pterygiophores, "Flossenstrahlenträger"). It is of course not permissible to count a split ray as two or a coalesced pair as one.

In the case of the vertebrae the complications are more numerous and more difficult to interpret. In an earlier paper (*Journal du Conseil,* Vol. VII, 1932, p. 373) the author has given a preliminary account of the two kinds of concrescence which may occur: 1) true fusions with signs of a suture in the centre; and 2) complex vertebrae, without indications of fusion but with accessory spinal processes on one or both sides. The second anomaly is only to be found in the first vertebra and in the last one, immediately before the urostyle.

It can easily be understood why the author makes this distinction. In the true fusions ("echte Wirbelverwachsungen") the number of coallesced vertebrae is recognizable and the counting therefore offers no difficulties.

The origin of the complexity of the first and last vertebrae, however, is uncertain and it is therefore impossible to state exactly which number they represent. The author shows clearly that in counting them either as one or as two the average number of all vertebrae never corresponds with the average obtained from a representative sample of plaice without any anomaly. He thus comes to the conclusion that the usual method in counting vertebrae, i. e., taking a complex vertebra for one, only can give reliable results if the proportion of individuals showing this anomaly to the normal ones in all localities is nearly the same. As this is, however, by no means the case and this proportion, being the resultant of numerous unknown factors, evidently must vary too from year to year, it seems preferable in using this character in racial investigations to discard all abnormal individuals.

In doing so, K ä n d l e r found that the "normal" plaice of the Baltic proper has the highest average, 43.07, and those of the Western Baltic the lowest, 42.81, the North Sea plaice being intermediate, 43.01. The corresponding averages for the anal fin rays are 52.04, 50.55 and 54.10 (cf. the table on p. 91).

In view of the fact that the formation of complex vertebrae has to be regarded as a reduction-process, the author finally comes to the conclusion that it is doubtful whether the number of vertebrae can be used at all as a racial character.

In an appendix the author reports upon certain abundant catches of young plaice (0-group, year-class 1934) from the Bornholm Deep, showing the same morphological characters as the adult fishes spawning on that ground. In consequence the hypothesis of an abnormal invasion of fry from the adjoining waters into the Baltic seems to be perfectly superfluous in attempting to account for their abundance in that year.

H. C. R.

A. R. Molander. "Further data concerning the witch *(Pleuronectes cynoglossus* L.)." Svenska Hydrogr.-Biol. Komm. Skr. N. S. Biol., Bd. I, Nr. 6. Stockholm, 1935.

Es wird zunächst ein Überblick über die schwedische Fischerei auf Rotzungen gegeben, die ausschliesslich durch Fischer von Bohuslän im Skagerak, Kattegat, in der Nordsee und unter Island ausgeübt wird. Die grössten Anlandungen wurden 1919 und 1920 erreicht. Eine starke Abnahme erfolgte 1927, verursacht durch die Einführung eines Mindestmasses von 30 cm., jedoch haben von 1930 ab die Anlandungen wieder zugenommen. Diese Zunahme ist auf eine Ausdehnung der Fischerei in der Nordsee zurückzuführen. Bis zur Einführung des Mindestmasses nahm die Zahl kleinster Rotzungen in den Fängen zu, während der Prozentsatz später wieder zurückging. Bestandsaufnahmen haben gezeigt, dass im Skagerak und Kattegat die Rotzungen früher (1913—17) hauptsächlich in den Gebieten unter 100 m. Tiefe anzutreffen waren, wo später (1921—28) ein starker Rückgang festgestellt wurde, sodass der Fang nicht mehr lohnend war. Es ist in den Fängen der letzten Jahre aus dem Skagerak aber keine wesentliche Abnahme der grossen Rotzungen im Verhältnis zum Gesamtfang erfolgt.

Betreffs der Verbreitung der Rotzungen wird zunächst betont, dass sie Schlickgrund vorziehen. Ihre Nahrung besteht zur Hauptsache aus Polychaeten, kleinen Muscheln und Stücken von Pennatuliden. In der Nordsee beschränkt sich ihr Vorkommen hauptsächlich auf Tiefen zwischen 100 und 200 m., im Skagerak zwischen 150 und 300 m. Im Skagerak zeigten die Untersuchungen, dass vom März bis Juli die Fänge beträchtlich zunahmen, vom Juli bis Februar sich aber stark verminderten. Diese Veränderungen zeigten sich in allen Tiefen, am stärksten jedoch in grösseren Tiefen. Es wird als unwahrscheinlich bezeichnet, dass eine Zu- und Abwanderung von anderen Gebieten erfolgt. Eine Laichwanderung erfolgt sicher, doch kann diese allein nicht die genannte Erscheinung erklären. Wahrscheinlich spielen hier hydrographische Ursachen eine Rolle. Wanderungen sind nur von örtlicher Bedeutung, abgesehen von der Laichzeit sind die Rotzungen sehr stationär. Ähnlich wie im Skagerak liegen die Verhältnisse in der Nordsee. Auch hier sind etwa die gleichen jahreszeitlichen Schwankungen in den Fängen zu bemerken. Die Verteilung der Grössenstufen ist so, dass die grösseren Tiere in ihrer Mehrzahl im flacheren Wasser anzutreffen sind, die kleineren im tieferen Wasser. Die absolute Zahl der Individuen ist aber im flacheren Wasser geringer als im tieferen Wasser. Im Kattegat, wo die Rotzungen spärlicher und unregelmässiger vorkommen, sind sie nur in Tiefen von 40—70 m. anzutreffen.

Von grossem Einfluss auf die Verbreitung der Rotzunge ist wahrscheinlich die Temperatur des Bodenwassers, und die Verschiebungen, wie sie in den Fängen zum Ausdruck kommen, werden wahrscheinlich durch die Temperaturverhältnisse bedingt. Als Temperaturoptimum werden 6—7° C. genannt, als Salzgehaltoptimum 34—35 $^0/_{00}$.

Von besonderem Interesse sind die Laichverhältnisse, die hier nach den Reifezuständen der Gonaden untersucht sind. Die Hauptlaichzeit fällt in die Monate Juni—Juli, im Kattegat zieht sich das Laichen oft bis in den November und Oktober hinaus. Im Skagerak laicht die Rotzunge nur in geringem Umfange, sie wandert zum Laichen in die westlichen Teile nach dem Abfall zur Tiefe und nach dem W.- und SW.-Rand der Norwegischen Rinne. In der nördlichen Nordsee liegen die Laichplätze in Tiefen von 100—160 m. Im Kattegat erfolgt das Laichen in geringerem Umfange. Wegen der Unregelmässigkeit in den Salzgehalts- und Temperaturverhältnissen

ist hier die Fortpflanzung behindert, bei zu geringem Salzgehalt sinken die Eier zu Boden und entwickeln sich nicht. Molander kommt zu der Schlussfolgerung, dass das Skagerak und die tiefen Teile der Norwegischen Rinne zur Hauptsache Weidegründe für die Rotzunge sind, und dass die Ergänzung der Bestände hauptsächlich von den Schlickbänken der nördlichen Nordsee aus erfolgt.

Bezüglich des Zahlenverhältnisses der Geschlechter konnte festgestellt werden, dass die Weibchen in der Regel in der Zahl überwiegen. Nach der Tiefe zu scheint ausserdem die Zahl der Männchen noch weiter abzunehmen. Im Wachstum der Rotzungen konnten örtliche Unterschiede festgestellt werden, doch zeigte sich im Skagerak, trotz der hier erfolgten Abnahme der Bestände, keine Zunahme des Wachstums. Die Altersuntersuchungen haben keine durch ihre Individuenzahl besonders hervortretenden Jahrgänge ergeben. Die Bestandsergänzungen scheinen ziemlich gleichmässig zu erfolgen. Nur im Kattegat kommen Unregelmässigkeiten vor, wohl hervorgerufen durch die wechselnden hydrographischen Bedingungen.

In einem letzten Abschnitt streift Molander die Frage, ob es verschiedene Rassen von Rotzungen gibt. Die Zahl der Wirbel und Dorsalflossen ergab bei den Rotzungen aus der Nordsee und dem Skagerak eine grosse Ähnlichkeit. Abweichend hiervon sind jedoch die Wirbel- und Flossenstrahlzahlen bei den Rotzungen aus dem Kattegat. Da auch keine Laichwanderungen im Kattegat festgestellt werden konnten, sondern da man vielmehr nach vielen Anzeichen für dieses Gebiet einen eigenen Bestand annehmen muss, ist das Vorhandensein einer besonderen Rasse für das Kattegat sehr wahrscheinlich. Allerdings sind dort bisher weder Eier noch Larven der Rotzunge gefunden, aber andererseits ist auch deren Verfrachtung dorthin von der Nordsee her nicht festgestellt und ist auch unwahrscheinlich, besonders für so jugendliche Stadien, bei denen die Wirbelzahl noch nicht festgelegt ist.

Diese wertvolle Arbeit Molanders hat unsere Kenntnisse über Nutzfische wesentlich erweitert, da hier sehr eingehend ein Fisch behandelt ist, über dessen Biologie wir bisher noch recht wenig unterrichtet waren.

Schnakenbeck.

O. Nybelin. "Über Eier und Larven der Rotzunge *(Pleuronectes cynoglossus* L.)." Svenska Hydrogr. Biol. Komm. Skr. N.S. Biol. Bd. 1, Nr. 7. Stockholm, 1935.

Diese Abhandlung Nybelins über die Eier und Larven von *Pl. cynoglossus* bildet eine Ergänzung zu der Arbeit Molanders. Vor allen Dingen sucht Nybelin zunächst Klarheit zu schaffen über die Bestimmung der Eier und jüngsten Larven, wo teilweise bisher noch Schwierigkeiten bestanden. Auf Grund eingehender Untersuchungen werden hier Richtlinien für die Bestimmung der Eier gegeben, die es ermöglichen, die Eier nicht nur auf dem Entwicklungsstadium mit Sicherheit zu bestimmen, in dem die Embryonen bereits die charakteristische Pigmentierung der Rotzungenlarven erkennen lassen, sondern auch schon früher. Allerdings ist diese sichere Bestimmung noch nicht in den allerfrühesten Stadien möglich, sondern erst von dem Stadium an, in dem der Embryo sich über die Hälfte des Dotters spannt.

Betreffs der jugendlichen Larven weist Nybelin darauf hin, dass früher teilweise zwischen Larven von *Pl. cynoglossus* und *Pl. microcephalus*

Verwechselungen vorgekommen sind, so z. B. durch Cunningham. Diese Klarstellung ist durchaus berechtigt. Nur in einer Sache besteht noch eine Unklarheit. Nybelin hebt mit Recht als besonderes Unterscheidungsmerkmal zwischen den Larven von *Pl. cynoglossus* und *Pl. microcephalus* die für jede Form ganz charakteristische Pigmentierung hervor. Diese wird in der Weise charakterisiert, dass für *Pl. microcephalus* nur zwei "vollständige postanale Pigmentbinden" angegeben werden, für *Pl. cynoglossus* dagegen *drei* "vollständige postanale Pigmentbinden". Diese Art der Charakterisierung schafft eine Unklarheit, die vermieden wäre, wenn eine kleine, vielleicht nur schematische Skizze beigegeben wäre. Wenn man "vollständige" Pigmentbinde so auffassen soll, dass sie ganz, ohne Unterbrechung quer über den Körper verläuft, so wäre diese Art der Pigmentierung nur *Pl. cynoglossus* zuzuschreiben, während bei *Pl. microcephalus* alle Pigmentzonen unterbrochen sind, d. h. bei der zuletzt genannten Art liegen Pigmentgruppen in der Weise in Zonen angeordnet, dass sich jeweils Pigmentgruppen am ventralen und dorsalen Rand der Myomeren gegenüberliegen, aber in der Körpermitte durch Lücken voneinander getrennt sind. Entsprechend diesen derartig am Rumpf angeordneten Pigmentgruppen liegen andere Gruppen am Rand des dorsalen und ventralen Flossensaumes. So kommen also auch bei *Pl. microcephalus* Querbinden zustande, die man allerdings insofern als "vollständig" bezeichnen kann, als in jeder Querzone eine gleiche Anzahl von Pigmentgruppen liegt. Bei *Pl. cynoglossus* hingegen ist es anders, und gerade diese Eigenart ist ein ganz charakteristisches Unterscheidungsmerkmal gegenüber der anderen Art. Es wechseln nämlich am Rumpf immer vollständige und unvollständige Pigmentzonen miteinander ab. Die vollständigen Zonen reichen ganz über den Rumpf hinüber, die unvollständigen liegen nur am ventralen Teil des Rumpfes. Der dorsale Flossensaum ist unpigmentiert, der postanale Saum am Rande pigmentiert. Diese charakteristische Anordnung der Pigmentgruppen ist auch auf der von Nybelin beanstandeten Abbildung Schnakenbecks vorhanden, womit diese dann doch zu *Pl. cynoglossus* gehören würde. Wenn ferner für *Pl. microcephalus* nur zwei vollständige postanale Querbinden angegeben werden, so soll das wohl nur für die jüngsten Stadien gelten, denn bei späteren Entwicklungsstadien sind es, ohne die Pigmentzone an der Basis der Schwanzflosse, drei.

Weiter hat Nybelin die Laichplätze von *Pl. cynoglossus* nach dem Vorkommen von Eiern und Larven festgestellt. Danach befinden sich Laichplätze an geeigneten Stellen der mittleren und nördlichen Nordsee. Über grösseren Tiefen der Norwegischen Rinne und ebenso in seichteren Teilen des mittleren und östlichen Skagerak waren keine Eier anzutreffen. Diese wurden fast ausschliesslich westlich von 8°40′ O. angetroffen und in grosser Anzahl an der Südkante der Norwegischen Rinne über Tiefen von 75—150 m. Die Laichgebiete erstrecken sich also an dieser Südkante entlang östlich bis zum Gebiet von Hanstholm. Die Larven werden durch die Strömung nach Osten getrieben. Die Bodenstadien wandern in die grösseren Tiefen des Skagerak ab, von wo sie nach Eintritt der Laichreife wieder an die Laichplätze ziehen. Die Laichzeit scheint nicht scharf begrenzt zu sein und in den verschiedenen Jahren auch Schwankungen unterworfen zu sein. Doch sind die Monate Mai bis Juli als die Hauptzeit anzusehen.

Diese Untersuchungen über die Fortpflanzungsverhältnisse ergänzen die gesamten Untersuchungen über *Pl. cynoglossus* in wertvoller Weise und runden das so gewonnene Bild ab.

Schnakenbeck.

F. S. Russell. "Tunny Investigations made in the North Sea on Col. E. T. Peel's Yacht St. George, Summer 1933. Part I. Biometric Data." Journ. Mar. Biol. Assoc. N. S., Vol. XIX, No. 2. Plymouth, 1934.

Le thon d'Atlantique est-il celui de Méditerranée? Sont-ce les mêmes bancs qui passent Gibraltar, accomplissent un périple méditerranéen et retournent à l'Océan; ou bien des races locales distinctes se cantonnent-elles dans des aires d'habitat bien délimitées? La question préoccupe depuis longtemps les chercheurs et n'est point encore résolue.

Les apparitions régulières de thon en Mer du Nord, constatées ces dernières années, semblaient devoir aider à élucider la question. La création du "Fishing Tunny Club" pouvait faciliter les recherches. Nous devons à M. F. S. Russell de les avoir entreprises. Ses observations apportent à la solution du grand problème des migrations une première contribution.

C'est à bord du yacht du Cl. Peel avec la collaboration du spécialiste bien connu de la pêche du thon, le Cl. R. Stapleton-Cotton que l'expédition fut effectuée en août-septembre 1933 à la bordure nord et à l'ouest du Dogger-Bank.

Le programme de travail comportait:

I — des opérations et recherches en vue de l'étude des migrations:

a/ — par la méthode directe: marquage de poissons avec hameçons poinçonnés,

b/ — par la méthode indirecte des indices biométriques.

2 — une étude de la distribution du thon en mer du Nord en relation avec les conditions hydrographiques.

Le travail que nous examinons traite de la première partie de ce programme.

I — *Marquage du poisson.* La méthode est celle que nous préconisions dès 1927 pour l'étude des déplacements du thon: des hameçons préalablement marqués, montés sur des lignes trop faibles, sont offerts au thon qui les arrache en se ferrant. Les hains ainsi perdus peuvent par la suite être récupérés; la marque permet alors d'identifier leur provenance et de connaître le trajet parcouru.

Les hameçons adoptés par les membres du Fishing Tunny Club sont de différents types commerciaux mais portent dans la hampe deux trous ou trois encoches.

Le nombre des poissons qui ont été ainsi marqués en mer du Nord au cours de l'été 1933 dépasse la centaine.

Nous souhaitons au Fishing Tunny Club succès et prospérité afin que s'accroisse chaque année le nombre des marquages.

Toutefois, bien que ces essais constituent un progrès sur la méthode de Sella, il faudrait pour que les résultats soient exempts de toute critique qu'on ait la certitude qu'aucun hameçon du Fishing Tunny Club soit filé ailleurs qu'en Mer du Nord.

Tant que chaque pièce n'aura pas sa marque individuelle — un numéro d'ordre par exemple — et qu'un répertoire ne sera pas tenu des marquages effectués, un doute pourra subsister dont les partisans du "thon sédentaire" ne manqueront pas de faire état.

Le numérotage des hameçons est donc à conseiller.

Mensuration du poisson. M. Russell adopte comme mesures à effectuer celles recommandées par le Comité des Experts de Cadix. Il précise en outre certaines d'entre elles et en indique de nouvelles.

De ce fait les indices biométriques établis peuvent être utilement comparés

avec ceux indiqués par Frade (1931) pour le thon de l'Algarve et par Heldt (1927) pour le thon de Tunisie.

Les poissons examinés en Mer du Nord apparaissent ainsi différents des exemplaires de tailles correspondantes observés en Tunisie et au Portugal: les ventrales sont semblablement placées, mais les dorsales sont légèrement plus rapprochées en avant, la tête est moins grande et l'œil considérablement plus petit.

Il y a lieu toutefois de noter que tous les thons mesurés en Mer du Nord se classent dans la dernière moitié du dernier groupe G-4 établi par Heldt et qui comprend les individus de 2 m. à 2.60 m. En outre les thons de Mer du Nord ont été examinés la ponte accomplie alors que ceux d'Atlantique et de Méditerranée se trouvaient, lors des observations, en période de maturité sexuelle.

Certaines des différences observées peuvent peut-être s'expliquer de ce fait.

Aussi ne paraît-il pas opportun, ainsi que l'auteur l'indique lui-même, de discuter ces différences tant qu'elles ne seront pas formellement contrôlées par un nombre plus considérable de mensurations sur des grands thons de différentes régions et à diverses époques de l'année.

Les indices établis par M. Russell avec méthode et précision, définissent en tous cas les gros thons d'été de Mer du Nord.

Que de tels travaux — marquages et calculs d'indices — soient entrepris et renouvelés dans les différents pays que fréquente le thon, et la question des migrations, discutée depuis plus de vingt siècles, pourra être scientifiquement résolue.

H. Heldt.

E. Sivertsen. "Torskens Gytning. Med særlig henblikk på den årlige cyklus i generasjonsorganenes tilstand." Fiskeridirek. Skr., Ser. Havunders. Vol. IV, No. 10. Bergen, 1935.

It was found that a small proportion of comparatively old fish were still immature, among a company of 550 large cod kept for a year in the pool at Flødevig, but the observations lend no support to a suggestion, from Russian work in the Barents Sea, that the cod may only spawn in some of the years of its adult life. Other workers will welcome the descriptions of ripeness stages, in gonads examined both macro- and micro-scopically.

M. G.

D. C. G. MacKay and F. W. Weymouth. "The Growth of the Pacific Edible Crab, *Cancer magister* Dana." Journ. Biol. Board Canada. Vol. 1, No. 3. Toronto, 1935.

This useful paper is based on 20,000 measurements accumulated during a period of 20 years. Evidence was collected in three ways: by size frequencies for early stages, by tagging, and by moulting for increase per moult and the time interval between moults.

Small crabs of 5 mm. may increase nearly 40 % in width at moult while adults about 13 cm. increase 15 % in the case of males and only 10 % in the case of females. Large crabs moult annually; the persistence

of instar periods for two years being evidently extremely rare. Sexual maturity is usually attained in the fourth or fifth year. Eight years appears to be the average duration of the life of a Pacific crab, and as at that age they attain the "legal size" in British Columbia it would appear that the breeding stock is more fully protected there than elsewhere in the case of other well-known species.

Compared with *Cancer pagurus*, the European edible crab, the growth-rate of the Pacific species is about the same. Fig. 5 gives 115 mm. at 5 years, while Fig. 6 gives about 130 mm. which agrees closely with 131 given by *Meek* in 1918. The Pacific species appears to grow by rather larger steps and so has fewer instars, particularly in early life, than the European species. Also it is interesting to note that megalops of whatever size when changing into crabs give rise to crabs of approximately the same width. "As a result, the size of the first post-larval instar is uniform."

R. E.

Current Bibliography.

Prepared by the Editor with the assistance of Miss Thursby-Pelham.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. Allen's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

Physical and Biological Conditions in the Sea.

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